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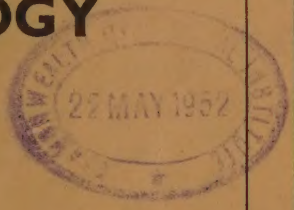

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(AGRICULTURAL RESEARCH SECTION)

CONTENTS

	PAGE
New Zealand Lamb and Mutton. I. Anatomical Characteristics of Lamb and Mutton Carcases. *E. A. Clarke* and *C. P.* McMeekan	1
New Zealand Lamb and Mutton. II. Chemical Composition of Edible Tissues. *C. R. Barnicoat* and *F. B. Shorland*	16
New Zealand Lamb and Mutton. III. The Nutritive Status of Lamb and Mutton Carcases. *E. A. Clarke* and *C. P. McMeekan*	24
The Composition of New Zealand Cheddar Cheese. *F. H. McDowall*	29
Lettuce Mosaic. *P. R. Fry*	52
Dissemination of White Clover (*Trifolium repens*) by Sheep. *F. E. T. Suckling*	64
A Botanical Survey of a Peat Area between Raumati South and Paraparaumu. *N. T. Moar*	78
Codling Moth Investigations in Nelson, 1948-49. *Avice Hamilton*	90
Spray Treatments for Control of Leaf Roller (*Tortrix Postvittana* Walker) in Apple Orchards. *G. G. Taylor*	98
The Effects of Chemicals and Antibiotic Substances on Crown-gall (*Agrobacterium tumefaciens* (Smith and Townsend) Conn.). Part IV. *D. W. Dye*	104
Coleophoridae (Lep.) as Pests of Clovers. *L. J. Dumbleton*	109
Chinese Gooseberries (*Actinidia chinensis*): A Survey of their behaviour in Cool-storage at all stages of Harvest Maturity from May to July. *C. A. S. Padfield* and *F. L. Bailey*	113
Directory of New Zealand Science	118
Comparative Animal Physiology	120
A Synopsis of the World Literature on the Fruit Tree Red Spider Mite *Metatetranychus ulmi* (C. L. Koch, 1835) and its Predators	119

NOTICES

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NEW ZEALAND LAMB AND MUTTON

PART I. ANATOMICAL CHARACTERISTICS OF LAMB AND MUTTON CARCASES

By E. A. CLARKE* and C. P. MCMEEKAN†, Ruakura Animal Research Station, Animal Research Division, Department of Agriculture, Hamilton

(*Received for publication, 30 January 1951*)

Summary

(1) A brief description of the general structure of the fat lamb and mutton industry in New Zealand is presented. The basic features of production, processing and grading are discussed.

(2) The results are presented of the carcase measurements and anatomical dissection data in terms of bone, muscle and fat for all the major export grades of lamb and mutton.

(3) The data show the significant features of the export grading system. The carcase measurements and dissection results obtained provide an objective backrgound to subjective grading practices. It is clearly shown that the chief distinction between quality and weight grades is relative state of fatness.

(4) Mutton is shown to differ from fat lamb mostly in respect to state of fatness ; this and associated differences are in keeping with the greater maturity of the ewe and wether carcases.

(5) The amount and percentage of bone, muscle and fat in the different joints of both mutton and lamb establish important and well defined differences. These are also in line with the relative rate of development of the different parts and tissues of the body.

INTRODUCTION

IN 1942, the authors were requested by Dr. John Hammond of the School of Agriculture, University of Cambridge, on behalf of the British Ministry of Food, to supply data upon the make up of the carcase and its different joints in terms of the amount of bone, muscle, and fat tissues ; upon the chemical composition of the edible tissues ; and upon the calorific and protein yield of the principle grades of New Zealand export quality lamb and mutton. This information was required for the

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† Formerly Canterbury Agricultural College, Lincoln.

effective organisation of food rationing and the determination of food import policies under the conditions arising from World War II. Existing information was restricted to what the text books described as " a typical lamb chop " or a " beef steak " in so far as our most important meat animals were concerned. Practically no data existed on the make up of the carcase as a whole, or of its component parts.

The urgency and magnitude of the project made it necessary to secure all possible assistance. The Department of Scientific and Industrial Research undertook financial responsibility for the equipment, labour and material, while the resources of the Agricultural Colleges and the Chemical Section of the Animal Research Division of the Department of Agriculture were mobilised on a co-operative basis. It must be emphasised that without this co-operation the completion of the task would have been impossible in the short time limit of three months which was imposed.

TABLE I. GRADES OF NEW ZEALAND LAMB AND MUTTON CARCASES EXAMINED

Description	Grades	Weight Range * (lb)	Carcasses Selected	Average Weight ** (lb)
North Island				
Down cross lambs	2's	Up to 36	10	32.2
	8's	37 - 42	10	39.6
	4's	43 - 50	10	46.2
Prime cross lambs	2's	Up to 36	10	32.1
	8's	37 - 42	10	39.5
	4's	43 - 50	10	46.1
Second quality lambs	Y's	Up to 36	10	30.5
Ewes	1's	Up to 48	5	44.7
	7's	49 - 56	5	52.6
	3's	57 - 64	5	60.4
	9's	65 - 72	5	68.6
	5's	73 - 80	5	76.5
Wethers	7's	49 - 56	5	53.3
	3's	57 - 64	5	61.0
	9's	65 - 72	5	69.5
	5's	72 - on	5	76.9
Second quality wethers	X's	Up to 56	5	46.5
South Island				
Prime lambs	2's	24 - 36	10	32.3
	8's	37 - 42	10	39.4
	4's	43 - 50	10	46.7
Second quality lambs	Y's	Up to 36	10	31.2
	YH's	37 and over	10	39.3
Ewes	1's	Up to 48	5	41.5
	7's	49 - 56	5	53.5
	3's	57 - 64	5	61.8
	9's	65 - 72	5	69.3
	5's	73 - on	5	78.8
Wethers	1's	Up to 48	5	43.1
	7's	49 - 56	5	53.4
	3's	57 - 64	5	60.2
	9's	65 - 72	5	68.7
Second quality wethers	X's	Up to 56	5	42.5

Note (*) Hot weight less 4½ %.
(**) Actual weight ex store.

Twelve grades of lamb, ten of ewe mutton and ten of wether mutton were dealt with (Table I). The sample comprised ten lambs, five ewes and five wethers in each grade. North Island and South Island carcases were handled separately. The carcases were selected on a restricted random basis from commercially graded lots so that the weight range within each grade was covered adequately. All lamb carcases had been in cool store for at least three months, and ewe carcases for one month.

The size of the sample was unavoidably small. The impossibility of handling a larger proportion of the total population may be gauged from the fact that even the sample taken involved 220 carcases and up to 80 man hours per carcase in dissection work alone.

GENERAL STRUCTURE OF THE LAMB AND MUTTON TRADE

As a background to the examination and discussion of the results of this study, a brief outline of the mutton and lamb industry of New Zealand is required.

Production

In the first place it is important to emphasise that considerable differences exist in the major characteristics of the industry in the North and South Islands, though in both cases, the industry is founded mainly on the use of dual purpose " cast-for-age " ewes from hill country, mated on fattening country to specalised or improved mutton breeds. In addition, surplus wether-lambs and wethers from the hill country dual purpose flocks supply an important source of fattening stock.

In the North Island the dual purpose breeding flocks are mainly of the Romney Marsh breed. The flocks are not purebred and are popularly known as " Romney Cross-bred " having been graded up from an original Merino base by the use of British Longwool breeds amongst which the Lincoln, English Leicester, Border-Leicester and Romney have predominated. During the last forty years, the Romney ram has assumed virtually complete dominance in this grading up process, so that for all practical purposes North Island flock sheep may be considered to be Romneys. A picture of this process can be gained from the data of Table II, showing the breed-composition of the rams used over the last 45 years.

TABLE II. BREED COMPOSITION OF RAMS USED IN NEW ZEALAND OVER PERIOD 1901-45

Breed	North Island				South Island			
	1901	1921	1935	*1945	1901	1921	1935	1945
Merino	4.59	0.59	0.2	0.01	24.05	7.96	7.2	4.9
Lincoln	62.16	13.62	0.9	0.5	9.68	1.74	0.4	0.2
Romney	19.59	73.78	62.4	65.6	11.77	30.86	36.3	40.1
Border Leicester	2.39	1.04	0.4	0.01	17.52	16.50	9.3	4.9
English Leicester	5.38	0.74	0.6	0.01	21.94	16.41	8.2	2.8
Shropshire	2.16	0.42	0.1	0.02	7.20	1.51	1.3	0.5
Southdown	1.56	9.03	32.5	32.4	1.35	1.50	11.8	24.7
Corriedale, ½B. & others	2.17	0.78	2.7	1.0	6.49	23.52	26.2	21.9

The fat-lamb farmer buys " cast-for-age " ewes (mainly 5½-year-old) of this type from the hill country to mate with the Down ram which today is primarily of the Southdown breed. Ewes of younger ages are used in limited numbers by some farmers. All lambs bred are slaughtered for meat, the larger proportion being so called " milk lambs ", sold fat off the mother. Lambs unfinished at weaning are practically all fattened and slaughtered before the winter. Production is almost entirely confined to pasture feeding. Very little crop fattening is practised at the present time except in localised areas. Under favourable conditions all lambs in the flock are fattened off the mothers on grass. After having produced for one or more seasons in this way, the breeding ewes are themselves killed for mutton.

In addition to specialised fat-lamb production of this type the wether lambs from hill country breeding flocks, along with cull ewe lambs are an important source of export lamb. Those fat at weaning—a proportion which varies markedly with locality and season—are sold direct to the freezing works, whilst the stores may be marketed as such to fatteners to provide fat lambs during the current season. A proportion of these, however, are used for farming the poorer quality dry-sheep hill country, eventually to become a source of wether mutton as two- and four-tooth sheep.

In the South Island, the ewe flocks used for fat-lamb production are of a mixed-breed population, consisting mainly of cast-for-age ewes from the Halfbred, Corriedale and Romney flocks on the breeding country. The two former breeds predominate. The rams used are also of a very mixed breed composition, the Southdown, Border Leicester, Ryeland, Suffolk, Dorset Horn, English Leicester, and crosses of these being employed.

Except for the district of Southland where the system of production is more comparable with the North Island, the proportion of lambs sold fat off the mother is substantially lower than in the North Island. In consequence, a large proportion of lambs are finished on crops, which are also employed extensively to fatten the unfinished wether lambs from the breeding flocks.

Processing

Some 33 Freezing Works, located at strategic points in relation to production areas and port facilities, slaughter, grade and freeze fat stock for export. The picking of the fat stock on the farms is carried out by meat operators who may actually be representatives of the Freezing Companies. The farmer is paid on a basis of standard schedule prices laid down by the New Zealand Meat Producers' Board, and based on dressed weight and quality grade[1] on the hooks at slaughter. To secure a uniform standard throughout the Dominion, grading is under the supervision of the Meat Producers' Board ; although it is actually carried out by employees of the meat export companies.

Grading

The various grades of lamb and mutton have been set out in Table I. In the grading of lamb it will be noted that weight is of prime importance. Within each weight-range there are quality grades in the North Island based on conformation and finish, the Prime Down-cross lambs being of superior down-type conformation and carrying a fat cover above a minimum standard. The Prime Crossbred lambs, have the conformation more typical of the long wool breeds with less finish than Down-cross,

Second quality lambs are typically unfinished carcases. It must be emphasised that each carcase is graded on its merits with no reference to its breeding. Although the Prime Down-cross grades comprise largely Down-cross Romney lambs, many straight Romney lambs of suitable conformation and finish are placed in this grade. Likewise, Down-cross Romney lambs lacking conformation and/or finish are relegated to the Prime Crossbred or Second Quality grades.

In the case of wether mutton, however, the main difference between prime and second quality is finish, or state of fatness. It will be noted that in the case of ewe mutton, the grading is based on weight only. Ewes and wethers failing to reach an adequate standard of fleshing are rejected as unexportable. Similarly, carcases failing to pass a strict system of inspection are rejected as unfit for human consumption.

A more complete discussion of the grading system has been published by Barton[2], while the annual reports of the New Zealand Meat Producers' Board set out the annual statistics including yearly prices of the various grades.

TABLE III. AVERAGE WEIGHT OF LAMB, WETHER AND EWE CARCASES EXPORTED FROM NEW ZEALAND DURING THE PERIOD 1923-24 TO 1948-49

Season	Weight of carcases		
	Wethers (lb)	Ewes (lb)	Lambs (lb)
1923 - 24	55.9	55.1	34.1
1924 - 25	57.6	57.2	35.4
1925 - 26	54.6	54.1	34.3
1926 - 27	55.9	54.5	34.8
1927 - 28	56.4	54.7	34.5
1928 - 29	58.0	55.3	34.9
1929 - 30	55.4	54.2	34.3
1930 - 31	53.0	53.2	33.2
1931 - 32	52.9	52.2	32.8
1932 - 33	55.1	52.9	34.1
1933 - 34	54.7	54.4	34.2
1934 - 35	53.2	53.5	32.7
1935 - 36	54.9	52.7	34.0
1936 - 37	54.3	53.8	33.7
1937 - 38	52.8	52.3	32.7
1938 - 39	53.1	52.9	32.8
1939 - 40	53.6	54.0	33.6
1940 - 41	55.2	53.9	34.7
1941 - 42	55.3	55.0	34.3
1942 - 43	54.3	54.4	33.5
1943 - 44	55.1	53.1	33.6
1944 - 45	58.4	57.1	34.6
1945 - 46	53.9	53.8	32.8
1946 - 47	60.0	57.5	35.4
1947 - 48	58.8	56.2	34.1
1948 - 49	59.4	57.2	35.5

In the South Island no Down-cross grade is sorted out. Instead, a Prime Canterbury Grade has been instituted which comprises lambs of the Down-cross Grade and the Prime Crossbred Grade in the approximate proportions of 30 : 70. In the selection of the South Island carcases for the present investigation this fact was taken into consideration.

This system of grading, along with price differentials tied mainly to weight grades with a bias toward light weights, has been based upon the preference of the Smithfield market in pre-war days for small meaty carcases and joints. In this way, the controlling authorities in New Zealand have directed the development of the fat-lamb industry so that the whole emphasis on the production side is towards the production of a light, blocky, well finished milk-lamb of 30-36 lb. dressed weight. This fact is emphasised in Table III[1] which shows the average weight of lambs, wethers and ewes exported for the last twenty-five years. Most of the variations existing may be explained in terms of seasonal variations in feed supply.

The proportions of the various grades of lamb exported over the last seven seasons are shown in Table IV[1]. It will be noted from Tables III and IV that there is a correlation between the mean carcase weight and the proportion of lambs falling into the different grades. When the average carcase weight is high, the precentage of Down-cross lambs is high and the percentage of Second Quality is low.

TABLE IV. GRADING OF LAMBS KILLED FOR EXPORT

Season	Percentage of total in various grades				
	1948/49	1946/47	1944/5	1942/3	1940/1
North Island					
Prime Down Cross	51.7	48.3	37.5	31.1	35.7
Prime Crossbred	35.5	34.3	34.4	34.4	35.0
Seconds	12.8	17.4	28.1	34.5	29.3
South Island					
Prime Canterbury	83.1	75.8	75.5	71.4	70.1
Seconds	16.9	24.2	24.5	28.6	29.9

Price differentials on a basis of weight and quality apply also to wether mutton, but in respect to ewe mutton, price varies only with weight. In each case, the grades listed in Table I are not all differentially priced at the present time, several weight grades being combined at the same price level.

Full details of the total killings for export of lamb and mutton are presented in the Meat Producers' Board Annual Reports.[1] The importance and size of the industry can be gauged from the fact that over the last five years some 11 million carcases of lamb, $2\frac{1}{4}$ million carcases of ewe mutton and $\frac{3}{4}$ million carcases of wether mutton have been killed for export each year.

EXAMINATION OF ANATOMICAL CHARACTERS

Technique of Selection and Dissection of Carcases

The general basis of selection of the carcases for this study has already been described. The North Island carcases were obtained from the longburn Freezing Works, and the South Island carcases from the Islington Freezing Works, Canterbury. It was considered by those intimately connected with the trade that the lambs from these two areas were fairly representative of the products of each island. Lambs were held in the freezing chambers in " bays " each of 500 lambs. One " bay " per weight grade was selected at random. Ten lamb, five ewe and five wether carcases, were selected from each " bay " on a restricted weight basis so that the complete range of weight of the grade was represented, and the average weight of the ten equalled the average weight of the grade. In the South Island lambs, each series of ten also included three carcases of Down-cross type to cover the thirty per cent of such carcases normally included in the Prime Canterbury Grade. Some difficulty was experienced in securing representative ewe carcases in the South Island, where, owing to the multiplicity of breeds and crosses, a light weight ewe, for example, could be either a small animal in good condition or a large animal in poor condition. With the aid of expert graders this difficulty was overcome as far as was practicable. In the North Island ewes, this problem did not arise because of the much more general uniformity of the Romney ewe flocks.

The dissection technique was essentially that developed at Cambridge and described by McMeekan[3] and Palsson[4]. The loin was separated from the thorax so as to include the last thoracic vertebra in the loin joint. All carcases were dissected in the defrosted or semi-defrosted condition. Dissection losses were of an unusually low order and seldom exceeded 1 per cent. This may be attributed to the employment of twenty or more technicians per carcase who were able to handle two animals per day at a high speed and level of efficiency. The following carcase measurements described by Palsson[4] were also taken :

A: Length of eye muscle.

B: Depth of eye muscle.

C: Thickness of back fat over thickest part of eye muscle.

G: Width of gigots.

T: Length of Tibia and Tarsus.

Owing to the carcases having been " telescoped " to facilitate export under war time conditions of restricted shipping space, it was not possible to take any other measurements[4] with accuracy.

Carcase Measurement Data

The mean measurements for lambs are presented in Table V.

It will be noted that within grades there is a general and orderly increase in all measurements with increasing weight. This increase is relatively greater in the fat measurement C than in the bone measurement T, the fleshing measurement G, and the muscle measurements

A and B. In the case of the North Island Down 8 grade, the low measurement for C suggests a state of fatness lower than is probably typical for this grade. This suggestion is supported from the dissection results (Table VII).

TABLE V. MEAN MEASUREMENTS OF LAMB CARCASES

Origin and grade of carcases		T (cm)	G (cm)	A (mm)	B (mm)	C (mm)
North Island						
Prime	2's	17.8	21.1	53.3	27.6	4.5
Down-cross	8's	18.7	21.7	54.1	28.4	4.8
	4's	19.0	22.9	59.8	30.5	7.2
Prime	2's	18.2	21.2	56.7	26.6	2.7
Crossbred	8's	19.3	21.7	61.3	26.2	4.0
	4's	21.2	23.4	59.9	27.8	5.1
Seconds	Y	19.3	22.3	54.5	24.0	1.8
South Island						
Prime	2's	17.6	20.0	52.4	28.6	4.6
Canterbury	8's	19.9	20.5	55.1	26.7	6.5
	4's	20.7	22.0	58.6	29.6	8.0
Seconds	Y	19.3	20.1	55.0	21.9	3.6
	YH	20.1	21.2	56.8	25.3	3.8

NOTE:—In the above Table and in Tables VII-X 2's, 8's, and 4's are the weight subdivisions of the three main quality grades.

TABLE VI. MEAN MEASUREMENTS OF EWE AND WETHER CARCASES

Origin and Grade of carcase		F (cm)	T (cm)	G (cm)	A (mm)	B (mm)	C (mm)
Ewes	1's	27.4	20.5	24.6	59.0	24.5	5.1
	7	27.5	21.2	26.5	58.2	25.8	7.5
	3	26.3	20.5	27.1	61.9	28.0	9.5
	9	25.4	21.1	27.8	61.2	32.3	10.3
	5	26.1	21.7	28.4	60.7	29.1	14.8
Wethers *	1	26.2	21.5	22.7	57.2	24.5	4.6
	7	26.5	23.0	24.3	60.1	27.3	8.5
	3	25.1	22.6	24.7	66.1	28.0	9.1
	9	26.2	23.4	25.6	63.4	28.8	12.0
	5	23.0	22.6	26.2	65.2	29.0	14.7
2nd Grade		26.7	22.4	23.0	61.3	24.5	4.1

* Wethers 1's S.Is. only
5's N.Is. only

Second grade lambs show G and A measures comparable with those of other grades, indicating a similar maturity in development in all but the late developing muscle depth B and fat cover C indicies. Between grades, the comparison of North Island Down-cross and Prime crossbred is of interest, since the differences shown provide an index of the real differences between these two grades, viz. a shorter leg (T). a comparable gigot width (G), a shorter but deeper eye muscle (A and B), and greater fat cover (C) in Down-cross lambs. It will be noted that the carcase measurements of Prime Canterbury Grade lambs resemble more closely those of the North Island Down-cross than the Prime Crossbred Grade.

The mean measurements of the ewe and wether carcases are shown in Table VI, which combines the North and South Island data. This bulking was made because no consistent differences could be observed between the product of the two Islands as represented by these samples and numbers. As might be expected with mature animals (ewes) and relatively mature animals (wethers), the only marked changes in measurements with weight are a slight increase in gigot width (G) and a marked increase in fat cover (C), both being capable of explanation as due to increasing fatness with increasing weight and age.

Composition of Lamb Carcases

The dissection results for the carcase as a whole and in terms of bone, muscle, fat, and tendon are summarised for lambs in Table VII.

It will be seen that New Zealand fat lambs contain from 10 to 15 per cent bone, 50 to 57 per cent of muscle and 22 to 36 per cent fat. A typical Down quality export lamb of 32 lb. weight thus consists of $3\frac{1}{2}$ lb. of bone, $16\frac{1}{4}$ lb. of muscle, $10\frac{3}{4}$ lb. of fat and 1 lb. of inedible tissue.

Within quality grades, there is a decrease in proportion of bone and muscle, and an increase in the porportion of fat with increasing weight. The only marked exception to this generalisation is the North

TABLE VII. ANATOMICAL COMPOSITION OF LAMB CARCASES

Origin and grade of carcases		Weight in grams				Percentage of total weight			
		Bone	Muscle	Fat	Tendon	Bone	Muscle	Fat	Tendon
North Island									
Prime	2	1567	7247	4819	498	10.9	50.5	33.6	3.5
Down-cross	8	1866	9090	5394	619	10.7	51.9	31.5	3.5
	4	2154	10325	7404	661	10.4	49.8	35.7	3.2
Prime	2	1819	6112	3846	557	12.5	56.0	26.5	3.8
Crossbred	8	2126	9332	5260	627	12.1	53.2	30.2	3.6
	4	2411	10902	6516	628	11.7	52.8	31.5	3.0
Seconds	Y	2002	7724	3000	569	14.7	56.8	22.1	4.2
South Island									
Prime	2	1650	7393	4556	341	11.7	52.5	32.4	2.4
Canterbury	8	2084	8661	6043	470	11.9	49.6	34.6	2.7
	4	2282	10587	7452	497	10.9	50.4	35.5	2.4
Seconds	Y	1843	7359	3991	377	13.4	53.6	29.1	2.8
	YH	2290	9344	5134	468	13.2	53.7	29.5	2.7

Island Down-cross 8 grade to which attention has already been drawn. Second quality lambs show heavier bone, better muscle development but a lower fat content than Prime grades.

Between the North Island Down-cross and Prime Crossbred grades the differences are of interest. Bone is both absolutely and proportionately greater in the Prime Crossbred; muscle tissue is similarly higher in this grade; but the Down-cross lambs show absolutely and proportionately higher fat figures.

South Island Prime Canterbury lambs are intermediate between North Island Down-cross and Prime Crossbred in general composition. The two South Island second grades are very similar and have better fat development than North Island second grade lambs.

Composition of Lamb Joints

Bone: Table VIII sets out the mean weights and percentages of bone in the different joints of each grade of lamb.

In all weight grades the percentage of bone increases in the following order: loin, pelvis, neck, legs, thorax and shoulder, the range being from 7 to 12 per cent in the loin, and from 12 to 17 per cent in the shoulders. In all joints there is an increase in absolute weight but in general a decrease in percentage of bone with increasing weight of carcase.

TABLE VIII. ANATOMICAL COMPOSITION OF LAMB CARCASES
BY JOINTS: BONE CONTENT

Origin and grade of carcases		Weight and Percentage of Bone in Joints											
		Neck		Shoulders(2)		Thorax		Loin		Legs(2)		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
North Island													
Prime	2	136	10.2	335	12.7	442	12.0	137	7.3	357	11.5	160	9.4
Down cross	8	164	10.5	402	12.4	519	11.6	171	7.4	420	10.7	190	9.4
	4	183	10.2	470	12.4	602	11.3	195	7.1	487	10.8	217	8.6
Prime	2	152	12.2	389	14.1	504	13.9	170	9.3	426	12.4	178	11.1
Crossbred	8	190	11.8	459	13.9	590	13.0	192	8.6	493	12.7	202	10.3
	4	229	12.2	522	12.7	655	12.8	206	7.6	570	12.5	229	10.1
Seconds	Y	178	13.7	434	17.1	547	16.2	180	11.6	462	14.0	201	13.2
South Island													
Prime	2	151	11.3	353	13.8	452	12.6	148	8.3	377	12.3	169	9.8
Canterbury	8	173	10.9	470	14.3	553	12.5	190	8.2	493	13.5	205	9.3
	4	187	10.4	495	12.4	614	11.3	200	7.3	548	12.5	238	9.0
Seconds	Y	161	12.4	410	15.5	495	14.3	159	10.3	433	13.9	185	11.3
	YH	203	12.2	494	14.9	617	14.4	203	9.6	539	14.0	234	11.0

South Island lamb in all joints tends to be intermediate between the two North Island quality grades. In both Islands second grade lambs have a higher percentage of bone in each joint than prime quality lambs; the percentage of bone is lower in South Island than in North Island carcases.

Muscle: Table IX compares the weight and percentage of muscle in joints of the different grades.

TABLE IX. ANATOMICAL COMPOSITION OF LAMB CARCASES
BY JOINTS: MUSCLE CONTENT

Origin and grade of carcases		Weight and Percentage of Muscle in Joints											
		Neck		Shoulder		Thorax		Loin		Legs		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
North Island													
Prime	2	618	46.2	1354	51.4	1697	46.0	969	51.8	1909	61.6	700	41.1
Down cross	8	752	48.3	1682	51.7	2129	47.5	1231	53.4	2437	62.3	859	42.7
	4	843	47.0	1181	49.6	2400	45.0	1385	50.1	2807	62.1	1009	40.0
Prime	2	636	50.8	1523	55.5	1854	51.0	1103	60.5	2248	65.2	758	47.4
Crossbred	8	810	50.3	1759	53.1	2192	48.4	1252	56.4	2462	63.3	857	43.6
	4	982	52.0	2135	51.9	2479	48.5	1414	52.3	2870	62.8	1022	44.9
Seconds	Y	658	50.6	1456	57.4	1783	52.9	987	63.6	2081	62.8	759	49.8
South Island													
Prime	2	664	49.6	1377	53.9	1659	46.1	940	52.7	2025	65.9	728	42.1
Canterbury	8	755	47.6	1694	51.6	1904	42.9	1099	47.6	2292	63.0	917	41.7
	4	869	48.3	2087	52.3	2367	43.6	1325	48.4	2821	64.4	1118	42.3
Seconds	Y	665	50.9	1465	55.5	1627	47.0	864	55.5	2009	64.4	729	44.5
	YH	837	50.2	1830	55.0	1997	46.5	1162	54.9	2520	65.5	998	46.8

Large differences exist in the percentage of muscle in the different joints. The legs carry the highest percentage, followed by the loin and shoulders which are very similar, and by the neck, thorax and pelvis in that order. The muscle content ranges from 62 to 66 per cent in the legs, and from 40 to 50 per cent in the pelvis. It is of interest to note that except for the South Island Prime lambs the loin carries more muscle than the shoulder. In general, second quality lambs carry a higher percentage of muscle in all joints, while South Island seconds have less muscle than North Island lambs of this grade. While the total muscle of the South Island lambs fall intermediate between the two North Island quality grades, this is not consistent for all joints. Thus the legs of the South Island lambs tend to carry more muscle.

TABLE X. ANATOMICAL COMPOSITION OF LAMB CARCASES
BY JOINTS: FAT CONTENT

Origin and grade of carcases		Weight and Percentage of Fat in Joints											
		Neck		Shoulder		Thorax		Loin		Legs		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
North Island													
Prime	2	511	38.2	811	30.8	1383	37.5	717	38.3	645	20.8	752	44.1
Down cross	8	548	35.2	962	29.6	1488	33.2	838	36.2	824	21.1	734	36.5
	4	685	38.2	1277	33.7	2133	40.0	1133	41.0	986	21.8	1190	47.0
Prime	2	384	30.7	703	25.6	1104	30.4	502	27.5	575	16.6	580	36.3
Crossbred	8	524	32.5	934	28.2	1544	34.1	731	32.9	718	18.5	809	31.2
	4	590	31.2	1307	31.8	1768	34.6	1036	38.3	900	19.7	915	40.2
Second Quality	Y	362	27.8	491	19.4	833	24.7	329	21.2	532	16.1	453	29.7
South Island													
Prime	2	482	36.0	718	28.1	1365	37.9	682	38.2	531	17.6	768	44.4
Canterbury	8	581	36.7	986	30.0	1831	41.3	986	42.7	671	18.0	988	44.9
	4	670	37.2	1275	32.1	2304	42.4	1188	43.4	815	18.6	1200	42.3

Fat : Table X compares the weight and percentage of fat by joints. The pelvis is outstanding as the fattest joint, followed by the loin, thorax and neck which do not differ greatly, shoulder and finally the legs which contain approximately 50 per cent of the fat of the loin joints. In the pelvis fat content varies from 30 to 47 per cent of the joint while in the leanest joint, the leg, the range is but from 15 to 22 per cent.

As in the case of muscle, there is a marked increase in the absolute weight of fat with increasing weight within quality grades. In contrast to bone which decreased and muscle which fluctuated the percentage of fat increased consistently with increasing weight of carcase.

Of special interest is the picture presented by the data for South Island legs. Whereas in other joints the tendency is for the fat content of the South Island joints to exceed even that of the North Island Down-cross grades, in the legs the fat content resembles that of the Prime Crossbreds. In other words, the South Island lambs appear to possess the general characteristics of Down-cross lambs rather than Prime Crossbreds except for their legs. It will be noted that the data of Table X brings out the major difference between the Down-cross and the Prime Cross grade in North Island lambs, the former carrying noticeably more fat in all joints, and, as a consequence, less muscle.

The data also emphasises the outstanding characteristics of Second grade lambs as fat lamb carcases—a marked deficiency of fat particularly in the later developing joints.

Composition of Ewe and Wether Carcases

In view of the small numbers involved and since close examination of the data revealed no significant trends as between the material from the two sources, the data from the two islands have been combined to facilitate examination.

Table XI shows the composition of the total carcase in terms of weight and percentage of bone, muscle and fat for both ewe and wether mutton.

TABLE XI. ANATOMICAL COMPOSITION OF MUTTON CARCASES

Type and grade of carcases		Weight in Grams				Percentage of Total Weight			
		Bone	Muscle	Fat	Tendon	Bone	Muscle	Fat	Tendon
Ewes	1's	2381	10819	5324	555	12.4	56.4	27.8	2.9
	7's	2528	11935	8169	594	10.8	51.0	34.9	2.5
	3's	2713	13554	9861	630	10.1	50.3	36.6	2.3
	9's	2927	15126	11730	657	9.5	49.2	38.2	2.1
	5's	2956	14796	15785	651	8.6	42.9	45.8	1.9
Wethers	1's	2245	10651	5796	484	11.6	55.0	22.9	2.5
	7's	2752	12359	7557	620	11.5	53.6	31.5	2.6
	3's	2948	14292	9125	647	10.9	52.6	33.6	2.4
	9's	3297	15333	11194	685	10.7	49.8	36.3	2.2
	5's	3270	15455	14242	779	9.6	45.4	41.8	2.3
	Y	2710	11365	5206	585	13.4	57.0	26.1	2.9

N.B. Wethers 1's South Island only.
5's North Island only.

The New Zealand mutton carcase thus contains from $8\frac{1}{2}$ to $12\frac{1}{2}$ per cent bone, 41 to 56 per cent muscle, and 23 to 46 per cent fat.

In both classes of mutton, the weight of each tissue increases in amount with increasing weight. On a percentage basis, bone and muscle both decrease in an orderly fashion, while fat increases. This picture is characteristic of the fattening process in mature animals. The picture presented by the second grade wethers is typical of a lean unfinished carcase.

It is worth drawing attention to the large amounts of fat involved in mutton carcases. The percentage ranges from 23 per cent, comparable with that of a second quality lamb, to 46 per cent which is ten per cent higher than that contained in the fattest grade of lamb examined. It is clear from the results that the greatest difference in gross composition between lamb and mutton is in the percentage fat.

Small differences exist between ewes and wethers. Wether carcases tend to carry more bone and muscle but less fat than ewe carcases of comparable weight.

Considering these results along with those already presented for lamb it will be seen that while all tissues increase they do so not equally but differentially. Thus the amount of bone shows the least change increasing from 1·6 kg. in Down-cross 2 lambs to 3·0 kg. in the heaviest mutton grade. Over the same range muscle increases from 7·2 to 14·8 kg., and fat from 4·8 to 15·8 kg. Similar changes in the relative proportions are also seen in the different joints. It is clear that the changes with weight are in accord with our knowledge of the laws of differential growth of the animal body. Bone, as the earliest developing tissue, shows the least increase; fat, as the latest developing tissue, the greatest increase. As weight of carcase increases over the complete range from lamb to mutton the proportion of edible meat increases rapidly. This is composed of an increasing proportion of fat relative to muscle. Relative percentage increases over the complete range are 80 per cent, 100 per cent and 240 per cent for bone, muscle and fat tissues respectively.

Composition of Mutton Joints

Bone: Table XII sets out the mean weight and percentage of bone in the different joints of the various grades of ewe and wether mutton.

TABLE XII. ANATOMICAL COMPOSITION OF MUTTON CARCASES
BY JOINTS: BONE CONTENT

Type and grade of carcases		Weight and Percentage of Bone in Joints											
		Neck		Shoulder		Thorax		Loin		Legs		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Ewes	1	239	13.0	488	13.5	710	14.3	207	8.4	491	12.5	247	10.5
	7	245	11.3	535	11.9	747	12.1	217	6.9	520	11.7	264	9.0
	3	277	10.5	552	11.1	797	11.4	247	6.4	556	10.9	283	8.3
	9	272	9.4	593	10.5	888	10.9	260	5.8	597	10.6	315	7.8
	5	282	8.3	616	9.8	893	9.5	249	4.9	607	10.4	308	6.9
Wethers	1	213	10.9	489	13.4	615	12.9	189	7.8	515	12.5	224	9.2
	7	266	12.0	595	13.0	765	12.6	230	7.3	621	12.3	273	9.4
	3	283	11.4	634	12.2	828	11.8	255	7.0	659	11.8	288	8.9
	9	332	11.5	711	12.4	944	11.6	273	6.5	704	11.4	332	9.0
	5	310	10.3	706	11.1	931	10.2	290	5.7	704	10.5	329	8.8
	X	258	14.2	575	14.9	763	14.9	222	10.1	623	13.8	267	11.5

In all weight grades of both types of meat the percentage of bone increases approximately in the following order: loin, pelvis, neck, thorax and shoulder, and legs, ranging from 5 to 10 per cent in the loin, and 11 to 15 per cent in the legs. In ewes, there is a very marked and orderly increase in the weight of bone in each grade with increasing weight of carcase. On a percentage basis, bone decreases with increasing carcase weight. Similar trends are seen in the wethers, but these are not so clearly defined. This is to be expected in a population relatively immature as compared with the ewe population. It should be noted that the general picture presented of bone-joint relationships closely parallels that seen in the different grades of fat lamb. As might be expected, second quality wethers carry a high percentage of bone comparable with the lighter grade of ewes.

Muscle: Table XIII shows the weight and percentage of muscle tissue on a joint basis.

TABLE XIII. ANATOMICAL COMPOSITION OF MUTTON CARCASES
BY JOINTS: MUSCLE CONTENT

Type and grade of carcases		Weight and Percentage Muscle in Joints											
		Neck		Shoulder		Thorax		Loin		Legs		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Ewes	4	1024	55.6	2068	57.4	2437	49.2	1390	56.3	2701	68.4	1198	50.8
	7	1107	57.0	2403	53.5	2692	43.5	1512	47.9	2935	66.2	1234	43.7
		1350	51.1	2649	53.3	2962	42.3	1785	46.5	3335	65.7	1473	43.2
	9	1449	50.0	2905	51.6	3331	41.2	2103	46.8	3650	65.7	1680	41.6
	5	1409	44.0	2880	46.0	3332	35.4	1963	38.8	3585	61.3	1545	34.5
Wethers	1	984	50.3	2134	58.5	2309	48.5	1294	53.3	2775	67.0	1155	47.2
	2	1153	52.0	2595	56.4	2856	46.9	1634	51.8	3292	65.3	1329	45.7
	3	1269	51.3	2800	53.9	3269	46.5	1820	49.9	3672	65.7	1460	45.2
	9	1449	50.0	3040	53.2	3514	43.1	1894	45.3	3911	63.2	1524	41.5
	5	1420	47.2	2904	45.6	3626	34.6	2116	41.5	3996	59.8	1391	37.3
	X	1018	55.8	2256	58.6	2580	50.5	1450	58.2	3003	66.7	1157	49.4

As in the case of lambs, the legs of both classes of mutton carry the highest percentage of muscle, ranging from 60 to 68 per cent. The least muscle tissue is found in the thorax and pelvis joints where it ranges from 35 to 51 per cent. Muscle increases in an orderly fashion with increase in weight in both classes, but decreases on a percentage basis. This trend is again more marked in the ewes than in the wethers.

Second quality wethers exhibit a high figure for muscle tissues, showing a strong similarity to the lightest grade of ewes in most joints. It is clear that the bone and muscle in New Zealand lamb and mutton carcases vary in a similar way.

Fat: Table XIV shows the weight and percentage of fat per joint.

Unlike lambs where the pelvis contained the most fat, the thorax and loin joints in ewe and wether mutton are very similar to this joint and have a high fat content. The remaining joints fall in the order: neck, shoulder and leg, the latter carrying easily the least fat of all joints. As in lambs, the fat content of the legs is only 50 per cent of that of the loin.

In all joints except the necks of wethers, there is a marked and orderly increase in weight and percentage of fat with increasing carcase weight. Second quality wethers are characterised by a low percentage of fat in all joints, carrying less than any other grade except in legs and pelvis where they are comparable again with the lightest grade of ewe.

TABLE XIV. ANATOMICAL COMPOSITION OF MUTTON CARCASES
BY JOINTS: FAT CONTENT

Type and grade of carcases		Weight and Percentage of Fat in Joints											
		Neck		Shoulder		Thorax		Loin		Legs		Pelvis	
		(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Ewes	1	506	30.4	909	25.2	1679	33.9	835	33.8	567	14.4	826	35.0
	7	737	33.9	1431	31.7	2574	41.6	1384	43.8	767	17.3	1275	43.4
	3	928	35.2	1630	32.8	3071	43.8	1751	45.7	952	18.7	1527	44.8
	9	1079	36.9	1976	35.1	3656	45.2	2060	45.9	1066	19.2	1898	46.9
	5	1513	44.7	2605	41.6	4985	52.9	2801	55.3	1405	24.0	2475	55.3
Wethers	1	684	35.0	900	24.7	1681	35.3	907	37.4	650	15.7	974	39.8
	7	717	32.4	1270	27.6	2246	36.9	1234	39.2	904	17.9	1184	40.8
	3	836	33.8	1604	30.9	2761	39.2	1542	42.3	1005	18.0	1376	42.6
	9	1015	35.0	1804	31.5	3437	42.2	1961	46.9	1302	28.1	1675	45.6
	5	1165	38.7	2518	39.5	4344	47.4	2627	51.5	1730	25.9	1858	49.8
	X	479	26.2	846	23.1	1595	31.4	715	31.0	702	15.5	825	35.1

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NEW ZEALAND LAMB AND MUTTON

PART II. CHEMICAL COMPOSITION OF EDIBLE TISSUES

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Summary

Chemical analyses of the edible portions of the commercial export grades of New Zealand lamb and mutton carcases showed the following extreme variations in composition: water, 38.2-58.8 per cent; fat, 24.4-51.4 per cent; protein residue, 10.4-16.9 per cent. Apart from the second quality carcases, the fat content tended to increase with the maturity of the animal. It was found that the edible tissues of the joints contained the following per centages of fat: thorax, 31.9-60.7; pelvis, 32.1-59.8; loin, 21.0-58.8; neck, 29.4-52.3; shoulders, 20.4-45.8; and legs, 14.5-27.0. The fat content of the dissected muscle showed considerable variation and appeared to increase with maturity; the leg muscle of lambs was found to contain on the average 4.6 per cent fat as compared with an average of 6.1 per cent in the ewes and wethers. The fat content of the dissected fatty tissues varied from 66.4 to 85.8 per cent, higher proportions being found in the joints of greater fat content.

A comparison of fatty tissues from the same joints indicated that the iodine values decreased with the age of the animal, and that the kidney fats had significantly lower iodine values than fats from other parts of the animal.

Introduction

In Part I[1] the average values for the composition of 30 carcases of each export grade of lamb and mutton with respect to dissected muscle, fat and bone are recorded. In the work here described the dissected meat tissues, consisting of muscle " marbled " with fat, and of fat containing its supporting network of connective tissue, were submitted to chemical analyses in order to obtain a measure of the chemical fat and protein contents of the edible tissue.

Experimental

Fat and protein analyses for South Island samples from carcases dissected at Canterbury Agricultural College, Lincoln, were carried out in the Chemical laboratory of the Animal Research Division, Department of Agriculture, Wellington. The North Island carcases were dissected and analysed chemically at Massey Agricultural College, Palmerston North. Because of these differences and the difficulties encountered in adapting the limited laboratory facilities available at both institutions to the large volume of work involved, and also because of the necessity for speed in carrying out analyses of perishable meat products, alternative methods of analysis were used in the two laboratories. Comparative tests made with the alternative methods in both laboratories showed, however, that the methods yielded similar results.

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Preparation and Preservation of Samples

The samples were minced finely in a mechanical mincer and reduced to a convenient amount by means of " quartering ".

Pending analysis the samples were preserved either by holding in tightly sealed jars at 0°-3°C. or by mixing with rectified spirits (250 g. minced meat with 70 ml. 95 per cent alcohol) in tightly sealed jars (for postage), and subsequently stored in a refrigerator.

Methods of Analysis :

(1) *Moisture:* Both muscle and fatty tissues were dried to constant weight either under vacuum at 100°C., or in an oven at 105°C. overnight.

(2) *Fat :* (a) *muscle tissues :* Extraction of dried muscle with petroleum or sulphuric-ether gives low results. Most of the triglyceride fraction present in " marbled " fat, is relatively easily extracted, but that portion associated with phospholipids and sterols in the " structural " lipids of the protoplasm—particularly the cell membrane and nucleus—is rather resistant to the action of the usual non-polar fat solvents. This resistant fraction is more readily dissolved after denaturation of the meat protein. The determination of total lipid material in meat muscle was therefore carried out in the following way : The minced muscle was mixed twice with 95 per cent alcohol, the alcohol being removed each time by distillation and finally by treatment in vacuo at 100°C. The dried, friable material was extracted with petroleum ether (b.p.40°-60°C.) first by decantation, then in a Soxhlet extractor. The extract was finally dried to constant weight in vacuo at 100°C.

(b) *Fatty tissues :* (i) by a modification of the method of Shorland, Hansen and Hogan[3], or (ii) by extracting the warm, molten, oven-dried material with petroleum ether (b.p.60°-80°C.) several times and decanting. The residue was freed from solvent and weighed, and the fat estimated by difference.

(3) *Protein :* The values for protein residues recorded in this section were estimated " by difference ", and really refer to fat-free residues. The protein contents of a number of muscle samples were determined by the Kjeldahl method, using the conversion factor N × 6·25. Comparative estimations of protein residues " by difference " and protein contents by analysis did not differ by more than 1·1 per cent, the former method yielding the higher values. According to Bate-Smith[3] the nitrogenous substances in meat comprise approximately 89 per cent only of true protein. To calculate true protein content he accordingly recommends the factor N × 5·6. Close agreement between the protein residue values (estimated " by difference "), as herein recorded, and the protein content as usually calculated (N × 6·5) was fortuitous, and did not allow for the presence of non-protein constituents, including minerals, carbohydrates, lactic acid, pigments, vitamins, etc. The true protein values would be less than the protein residue values recorded in the Tables I and II.

Results and Discussion

As the carcases had been held in storage at 14°F for 1-3 months prior to sampling, a certain amount of shrinkage due to loss of water (2-4 per cent) would inevitably have occurred. The values recorded in the tables for water are therefore somewhat lower than would have been found in recently killed animals, and the values for fat and protein residue would be proportionately higher.

TABLE I. COMPOSITION OF EDIBLE TISSUES OF JOINTS FROM CARCASES OF NEW ZEALAND LAMB AND MUTTON

(RESULTS EXPRESSED IN PARTS PER CENT BY WEIGHT)

A. NORTH ISLAND CARCASES

Joint	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein
LAMBS	Prime Cross 2's			Prime Cross 8's			Prime Cross 4's			Down Cross 2's			Down Cross 8's		
Neck	53.8	30.2	16.0	50.1	35.7	14.2	49.7	35.6	14.7	47.5	39.0	13.5	48.7	37.2	14.1
Shoulders	57.2	25.6	17.2	55.5	27.6	16.9	52.8	32.9	14.3	53.0	35.1	11.9	52.9	32.3	14.8
Thorax	50.2	34.8	15.0	46.8	39.9	13.3	45.1	41.4	13.5	43.2	45.8	11.0	45.3	41.6	13.1
Loin	54.5	27.3	18.2	50.0	35.1	14.9	47.0	38.3	14.7	44.6	41.5	13.9	45.7	39.7	14.6
Legs	64.7	16.0	19.3	62.8	19.6	17.6	62.0	19.7	18.3	60.9	22.1	17.0	61.8	22.2	16.0
Pelvis	49.9	35.5	14.6	44.2	43.1	12.7	44.7	41.8	13.5	44.7	43.2	12.1	46.2	41.5	12.3
	Down Cross 4's			2nd Quality Y's											
Neck	45.8	41.2	13.0	55.0	29.4	14.6									
Shoulders	50.7	35.1	14.2	62.1	20.4	17.5									
Thorax	41.8	45.9	12.3	53.2	31.9	14.9									
Loin	43.3	42.1	14.6	57.3	21.0	21.7									
Legs	60.0	22.8	17.2	67.1	16.0	16.9									
Pelvis	41.0	46.7	12.3	52.3	32.1	15.6									
EWES	1's			7's			3's			9's			5's		
Neck	53.2	31.8	15.0	47.0	37.7	15.3	48.3	38.0	13.7	45.7	39.8	14.5	42.6	44.1	13.3
Shoulders	54.9	28.6	16.5	48.1	37.5	14.4	49.0	37.2	13.8	46.6	39.9	13.5	43.0	44.1	12.9
Thorax	45.2	40.2	14.6	37.4	50.1	12.5	39.0	49.0	12.0	34.6	54.3	11.1	33.2	56.1	10.7
Loin	50.1	33.0	16.9	40.3	45.7	14.0	43.1	42.2	14.7	38.7	48.0	13.3	34.5	54.0	11.5
Legs	63.6	16.9	19.5	61.1	19.6	19.3	59.1	23.6	17.3	57.6	24.1	18.3	55.8	26.2	18.0
Pelvis	47.8	35.5	15.7	40.0	47.0	13.0	42.1	44.4	13.5	36.5	51.6	11.9	35.0	51.5	13.5
WETHERS	7's			3's			9's			5's			2nd quality X's		
Neck	49.5	35.9	14.6	47.0	39.2	13.8	43.8	42.5	13.7	42.5	45.1	12.4	53.2	30.9	15.9
Shoulders	53.6	31.2	15.2	51.0	34.1	14.9	46.8	39.5	13.7	43.4	43.9	12.7	57.4	25.5	17.1
Thorax	43.0	44.4	12.6	41.8	45.4	12.8	36.9	51.7	11.4	33.8	54.5	11.7	48.9	37.4	13.7
Loin	47.1	38.9	14.0	42.7	43.7	13.6	37.1	50.4	12.5	34.3	53.7	12.0	53.2	30.7	16.1
Legs	61.7	20.7	17.6	60.6	21.4	18.0	57.6	24.9	17.5	56.1	27.0	16.9	63.6	18.8	17.6
Pelvis	45.3	41.7	13.0	42.1	45.0	12.9	38.7	49.4	11.9	35.6	54.0	10.4	49.8	36.4	13.8

B. SOUTH ISLAND CARCASES

TABLE I. CONTINUED:

Joint	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein	Water	Fat	Protein
LAMBS	Prime 2's			Prime 8's			Prime 4's			2nd Quality Y's			2nd Quality Y H's		
Neck	49.6	36.3	14.1	48.2	39.6	12.2	47.9	39.4	12.7	50.7	35.6	13.7	50.4	35.5	14.1
Shoulders	55.2	29.0	15.8	54.0	31.9	14.1	52.1	34.0	13.9	58.3	26.0	15.7	56.3	28.4	15.3
Thorax	46.1	41.0	12.9	43.2	45.3	11.5	42.9	45.5	11.6	47.8	38.9	13.3	49.9	36.6	13.5
Loin	48.9	36.8	14.3	44.7	42.2	13.1	44.3	42.7	13.0	51.6	33.4	15.0	51.4	33.1	15.5
Legs	64.4	17.9	17.7	62.6	20.0	17.4	62.7	19.8	17.5	64.8	17.3	17.9	65.6	16.3	18.1
Pelvis	43.7	43.6	12.7	43.3	45.0	11.7	44.1	43.5	12.4	47.3	39.5	13.2	48.0	38.4	13.6
EWES	1's			7's			3's			9's			5's		
Neck	53.1	32.7	14.2	48.6	38.2	13.2	44.6	43.0	12.4	45.6	42.2	12.2	37.9	52.3	9.8
Shoulders	58.5	25.9	15.6	55.2	30.4	14.4	50.9	35.2	13.9	50.5	36.4	13.1	42.9	45.8	11.3
Thorax	47.0	40.1	12.9	42.2	45.5	12.3	37.2	52.5	10.3	40.8	48.5	10.7	31.0	60.7	8.3
Loin	50.1	35.9	14.0	46.3	42.7	11.0	38.2	50.8	11.0	43.2	44.8	12.0	32.0	58.8	9.2
Legs	67.1	14.5	18.4	64.3	18.0	17.7	62.1	20.1	17.8	64.2	17.7	18.1	58.1	25.9	16.0
Pelvis	49.7	36.9	13.4	45.9	43.0	11.1	39.9	48.6	11.5	44.0	43.7	12.3	31.6	59.8	8.6
WETHERS	1's			7's			3's			9's			2nd Quality X's		
Neck	50.9	35.6	13.5	49.8	35.8	14.4	51.7	34.2	14.1	48.6	37.3	14.1	54.9	28.6	16.5
Shoulders	58.9	25.4	15.7	54.9	30.3	14.8	54.5	31.1	14.4	52.3	32.7	15.0	57.5	25.8	16.7
Thorax	48.6	38.3	13.1	43.5	44.4	12.1	44.4	43.3	12.3	40.3	47.7	12.0	47.6	38.0	14.4
Loin	49.2	36.8	14.0	43.6	43.1	13.3	45.6	41.5	12.9	39.5	48.0	12.5	48.4	36.2	15.4
Legs	65.3	16.9	17.8	61.8	20.2	18.0	63.8	18.8	17.4	59.7	22.8	17.5	65.0	16.2	18.8

Composition of Joints

The average compositions of lamb and mutton joints from different weights and grades is recorded in Table I.

Composition of Carcases

The average compositions of the whole carcases of lamb and mutton have been calculated from data in Table I and from Tables VII-XIV (Part I[1]), and are recorded in Table II.

In Table II it will be seen that the extreme ranges in average composition are :

Water	38·2 - 58·8 per cent
Fat	24·4 - 51·4 per cent
Protein residue	10·4 - 16·9 per cent

Most of the variations in composition resulted from differences in fat content.

With the exception of the 2nd quality carcases, usually rejected through lack of " finish ", the fat content tended to increase with maturity of the animal. This is shown not only by differences in composition between carcases of lambs and ewes or wethers, but also, indeed, by differences between grades with any one type of carcase.

Variations in composition are responsible for differences in food values of carcases.

Chemical Compositions of Muscle and Fatty Tissues

Muscle Tissues : Chemical analyses indicated that dissected muscle tissues contained varying proportions of fat, some of which was doubtless present because of difficulties involved in separating mechanically all the visible fat from the flesh. A certain amount of fat occurs " marbled " with the flesh protein, however, and analyses of the muscle of the leanest joint (leg) indicated that 3·2 to 8·7 per cent (average 5·7 per cent) of fat occurred in this form.

The fat contents of leg joints varied from 14·5 to 27·0 per cent (Part I)[1] but there was no evident relationship between the total fat content of a joint and the percentage of " marbled " fat found by chemical analysis. Leg muscles of mature animals (ewes and wethers) contained, on the average, 6·1 per cent of fat, as compared with an average of 4·6 per cent in lamb tissues. It would therefore appear that while the process of fat deposition within the animal body is confined, in the main, to regions surrounding the flesh, these is also an increase in the " marbled " fat in tissues of older animals.

Fatty Tissues : Depot fats are laid down in a supporting network of connective tissue, hence they contain considerable proportions of protein and water. Variations in fat content of dissected fat ranged from 66·4 to 85·8 per cent. The fat contents of adipose tissue of the pelvis, thorax and loin were notably higher than that of the leg, the shoulder and neck being intermediate in this respect. The average compositions of adipose tissue from the loin—one of the fattest and most easily dissected joints—were as follows :—

	Percentage composition of loin depot fat		
	Fat	Water	Protein
Lambs	78·5	16·4	5·1
Ewes and Wethers	82·3	14·0	3·8

TABLE II. AVERAGE PERCENTAGE COMPOSITION OF NEW ZEALAND EXPORT LAMB AND MUTTON CARCASES.

A. NORTH ISLAND CARCASES

Type and Grade	Water	Fat	Protein (residue)
LAMBS			
Prime Cross 2's	55.8	27.3	16.9
" 8's	52.4	32.5	15.1
" 4's	51.0	34.1	14.9
Down Cross 2's	49.5	37.3	13.2
" 8's	50.9	34.8	14.3
" 4's	47.7	38.2	14.1
2nd Quality Y's	58.8	24.4	16.8
EWES			
1's	52.6	30.9	16.5
7's	45.4	39.9	14.7
3's	46.6	39.3	14.1
9's	42.9	43.5	13.6
5's	40.2	46.7	13.1
WETHERS			
7's	50.4	35.1	14.5
3's	48.0	37.5	14.5
9's	43.7	42.8	13.5
5's	40.3	46.2	12.9
2nd Quality X's	55.0	29.2	15.8

B. SOUTH ISLAND CARCASES

LAMBS			
Prime 2's	52.1	33.2	14.7
" 8's	49.7	36.8	13.5
" 4's	49.3	37.1	13.6
2nd Quality Y's	54.3	30.7	15.0
" " YH's	54.5	30.4	15.1
EWES			
1's	54.4	30.7	14.9
7's	50.4	36.2	13.4
3's	45.2	42.1	12.7
9's	47.7	39.4	12.9
5's	38.2	51.4	10.4
WETHERS			
1's	54.2	31.2	14.6
7's	49.9	35.9	14.2
3's	51.0	35.0	14.0
9's	46.8	39.3	13.9
2nd Quality X's	53.8	30.2	16.0

Triglycerides accounted for only about four-fifths of the adipose tissues, though the fats of the more mature (mutton) carcases contained less connective tissue than was found in the lamb carcases.

Assuming that all water was bound to protein, the ratio water : protein in connective tissue was 3·4 : 1, a result practically identical with that found for leg muscle, viz. 3·5 : 1.

Variations in Iodine Values of Carcase Fats

The iodine value of a fat is an index of its content of unsaturated fatty acids and is, in general, related inversely to its hardness. Representative samples of fats from joints of North Island carcases were obtained by combining the extracts from fat estimations, and their iodine values (Wijs) are recorded in Table III.

TABLE III. IODINE VALUES OF NORTH ISLAND LAMB AND MUTTON FATS

Joint	Lambs	Wethers	Ewes
Neck	49.5	47.1	44.4
Thorax	49.6	47.3	45.7
Shoulder	49.9	45.3	44.8
Loin	47.8	45.0	42.5
Pelvis	48.6	47.1	45.1
Leg	50.7	49.1	48.0
Kidney	43.5	41.6	38.9
Average	48.5	46.1	44.2

Note: Average age of lambs, 4-8 mt; wethers, 1-2 yr; ewes, 5½ yr.

It will be seen that the iodine values of the three types of carcase show well-defined and consistent trends. The iodine values of the various adipose tissues decreased with the age of the animal, and kidney fats (suet) were always the lowest; this accords with the generalisation that the internal body fats tend to be the hardest.

Relationship between Composition of Tissues and Whole Carcases

Because of the constant relationship between protein residue and water contents of meat tissues and a reciprocal relationship between these values and fat content (Table II), it has been possible to establish a series of regression coefficients by means of which the approximate chemical composition of carcases can be simply calculated with a fair degree of accuracy from the analysis of a representative sample of tissues from only one joint.

A paper dealing with this aspect of carcase composition, based on results recorded in full in this paper, has already been published[4].

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NEW ZEALAND LAMB AND MUTTON

PART III. THE NUTRITIVE STATUS OF LAMB AND MUTTON CARCASES

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Summary

(1) The approximate nutritive value of the different grades of New Zealand export lamb and mutton, is given in terms of total calories and protein on a per carcase and per joint basis.

(2) The total calorific value of both the lamb and mutton carcases is dependent mainly upon the state of fatness, calories per carcase being strongly correlated with weight of dissected fat per carcase. In consequence, on both a per carcase, per joint, and per kilo basis, calorie content increases with increasing weight.

(3) The total protein content of the lamb and mutton carcase and joint increases with increasing weight of carcase or joint, but on a per kilo basis, protein value decreases with increasing fatness, or with increasing weight within quality grades.

(4) Important differences between the nutritive status of different joints are shown.

INTRODUCTION

WHILE calorie content and protein yield by no means fully describe the nutritive status of a staple foodstuff, these characteristics do provide a gross measure of food value and are basic to food production and supply problems. Particularly is this so in periods of food shortage when, as a guide to policy decisions, such data are capable of contributing information without which sound decisions cannot be made.

The anatomical data of Part I[1] of this series, together with the chemical analysis data of Part II[2] permit an estimate to be made of the calorie and protein content of the products under examination. This paper presents the results of such estimates.

METHOD OF COMPUTING CALORIFIC VALUES

In computing the calorific value of the fat and protein, the physiological fuel values of 4 Cal per gram of protein, and 9 Cal per gram of fat have been used. The resulting calorific values are those normally employed in the description of the energy values of human foods, the figures having a similar significance to metabolisable energy.

NUTRITIVE STATUS OF LAMB CARCASES

Table I sets out the nutritive status of lambs in terms of Calories and protein per carcase and per kilogram, for each of the twelve grades.

In general terms, the data show a regular and orderly increase in the total calorific value of the carcase with increasing weight and increasing fat content of the different grades. The latter point is particularly emphasised by the data for calorific value per kilogram, where

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TABLE I. NUTRITIVE STATUS OF LAMB CARCASES

Origin and grade of carcases	Calorific Value		Protein Content		Ratio Protein/ Cal.(000's)
	Total (000's)	Per Kg	Total	Per Kg	
North Island					
Down Cross 2	46.9	1594	3.3	111	34
8	53.7	2070	3.1	118	39
4	70.9	2495	3.4	120	35
Prime Cross-bred 2	37.5	2008	2.6	137	53
8	51.5	2208	2.9	126	43
4	63.9	2609	3.1	126	41
Seconds	30.8	1806	2.3	133	59
South Island					
Prime Canter-bury 2	42.8	1759	3.0	125	41
8	56.6	1984	3.2	114	35
4	70.1	2452	3.3	117	35
Seconds Y	38.2	1702	2.8	124	45
YH	48.3	2193	2.8	126	45

it will be noted that Down-cross lambs have a much higher value than equivalent weight grades of Prime crossbreds. As in the case of fat content the South Island lambs resemble more closely the Down-cross grade. Second quality lambs in each island have a much lower nutritive value on an energy basis than the prime grades. The data show a similar but less steep trend in total protein value per carcase, with increasing weight. Prime crossbred lambs have a higher protein content than Down-cross and although this fact is not so marked as in the case of fat, the South Island Lambs again resemble Prime Down-cross, rather than Prime Crossbred. Second quality lambs show a high protein content for their weight.

It is of interest to compare the various grades of lamb from the viewpoint of protein per Calorie. In general, there is an orderly decrease in this ratio with increasing weight. The outstanding anomaly

TABLE II. NUTRITIVE STATUS OF LAMB JOINTS (EXPRESSED AS THOUSANDS OF CALORIES AND GRAMS OF PROTEIN PER KILOGRAM

Origin and Grade of Carcases	Neck		Shoulders		Thorax		Loin		Legs		Pelvis	
	Cal.	Prot	Cal.	Prot.	Cal.	Prot	Cal.	Prot.	Cal.	Prot.	Cal.	Prot.
North Island												
Down -cross 2	3.4	114	3.0	98	3.8	92	3.9	125	2.2	140	3.7	103
8	3.3	118	2.8	120	3.4	106	3.7	131	2.2	133	3.4	99
4	3.6	110	3.1	118	3.9	105	4.0	133	2.3	144	4.1	107
Prime 2	2.7	130	2.4	134	3.0	122	2.8	161	1.8	158	3.2	123
cross 8	3.1	117	2.6	138	3.4	110	3.4	133	2.0	144	3.7	108
bred 4	3.2	122	3.0	120	3.5	112	3.7	133	2.1	151	3.7	115
Y	2.6	122	1.9	134	2.7	116	2.3	184	1.7	133	2.8	124
South Island												
2	3.3	121	2.7	130	3.5	108	3.5	130	1.9	148	3.8	109
8	3.4	103	2.8	115	3.8	97	3.9	119	2.0	141	3.9	102
4	3.5	109	3.0	118	3.9	110	4.0	119	2.1	145	3.9	106
Y	3.1	114	2.4	127	3.5	109	3.2	132	1.8	145	3.5	112
Y8	3.2	119	2.6	124	3.2	111	3.2	138	1.8	146	3.4	116

is the North Island Down-cross 8's, which, as has already been pointed out, were leaner than thought to be characteristic of this grade. The extremely high protein Calorie ratio of second quality lambs might be noted, particularly in the case of North Island seconds.

While the calorific value per kilogram within quality grades increases with increasing weight, the protein value per kilo, with the exception of Down-cross grades, shows a decrease.

Nutritive Status of Joints of Lamb Carcases

Table II shows similar data for each joint.

The calorific value per kilogram varies in a fairly well defined manner between joints; thus, the Pelvis, Loin, Thorax and Neck stand out as the most nutritive joints on an energy basis, ranging from 4·1 Cal in the pelvis to 3·6 Cal in the neck of Down-cross 4's. The shoulder and legs have a substantially lower energy value on this basis, with the legs standing out as the least nutritive joint per kilo. It is important to note that this joint shows a very narrow range in this value in comparison with all other joints, which show fairly wide differences between quality grades of comparable weights. Nutritive value in these terms also shows fairly orderly increases with increasing weight within quality grades.

NUTRITIVE STATUS OF MUTTON CARCASES

Table III shows the calorific and protein values of the different grades of mutton for combined North Island and South Island carcases on a per carcase and per kilogram basis.

TABLE III. NUTRITIVE STATUS OF MUTTON CARCASES

Origin and grade of carcases		Total Cal. (000's)	Total Protein	Cal.(000's) Per Kg	Protein Per Kg
Ewes	1	55.0	2526	2.87	131
	7	80.2	2821	3.43	121
	3	98.3	3142	3.65	117
	9	114.4	3560	3.72	116
	5	149.6	3566	4.34	104
Wethers	1	55.8	2415	2.88	125
	7	76.9	2944	3.21	123
	3	89.8	3332	3.30	123
	9	112.5	3631	3.60	118
	5	139.4	3870	4.11	114
	X	54.9	2633	2.8	133

As in the case of lamb, gross nutritive value increases with increasing weight. This applies both to total Calories and to total protein content, the former showing a greater proportionate increase with weight than the latter.

On a kilogram basis, Calories increase and protein decreases in an orderly manner, in both types of mutton.

Of special interest is the close similarity shown in the nutritive value of ewe as compared with wether mutton. Apart from small fluctuation probably attributable to sample size, ewes show only a slightly higher total calorie content. This may be attributed to the greater fat content of ewe mutton.

Second quality wether mutton, in common with second quality lamb, shows relatively low calorie content and relatively high protein content on both a total carcase and a per kilogram basis. This is in line with the relative proportions of muscle and fat in this grade.

The all important part played by state of fatness in determining the total calorific value of the carcase is illustrated in Fig. 1 where the Calories per carcase are plotted against total weight of dissected fat for all grades of lamb and mutton. Deviations from the lineal relationship demonstrated are of small magnitude. The relationship is expressed by the following regression equation which has a very low standard error of estimate :

$$y = 9{\cdot}756\,x \pm 2{\cdot}03$$

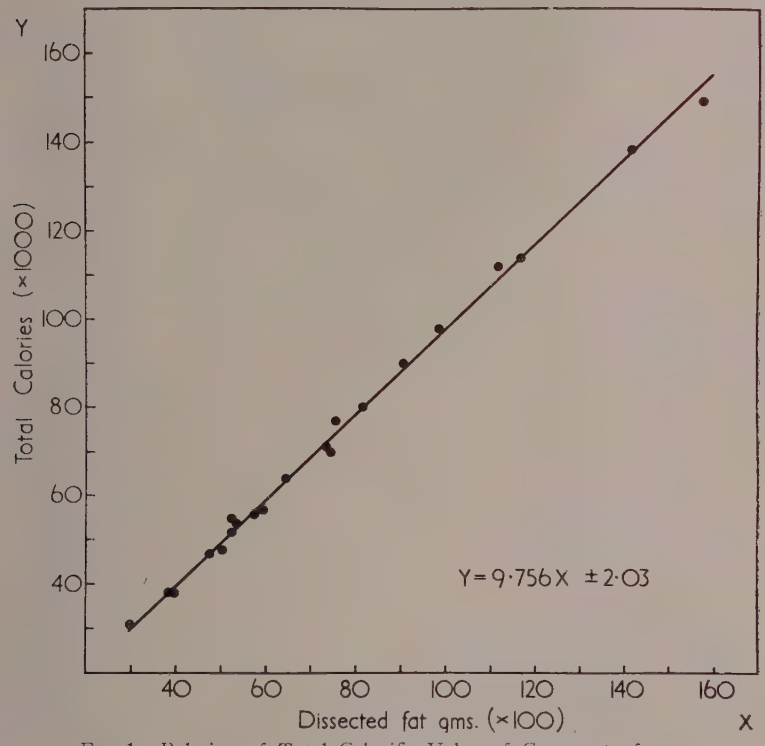

Fig. 1.—Relation of Total Calorific Value of Carcass to fatness.

Nutritive Status of Joints of Mutton Carcases

Table IV compares the calorific and protein value per kilogram of the different joints in both ewe and wether mutton. As for the previous comparisons, the data for both Islands are combined.

As in the case of lambs the calories per kilogram increase in each joint with increasing weight, while protein per kilogram decreases. These trends are even more definitely pronounced than in the lamb data. Second quality wether mutton appears to be closely similar to the lightest grade of both ewe and wether mutton, in each joint.

TABLE IV. NUTRITIVE STATUS OF MUTTON JOINTS (EXPRESSED AS THOUSANDS OF CALORIES AND GRAMS OF PROTEIN PER KILOGRAM)

Origin and Grade of Carcases		Neck		Shoulders		Thorax		Loin		Legs		Pelvis	
		Cal.	Prot.	Cal.	Prot.	Cal.	Prot.	Cal.	Prot.	Cal.	Prot.	Cal.	Prot
Ewes	1	2.9	118	2.6	133	3.4	114	3.4	139	1.8	158	3.3	124
	7	3.4	121	3.1	123	4.1	106	4.1	114	2.0	154	3.9	105
	3	3.6	113	3.3	119	4.3	96	4.3	119	2.3	148	4.1	110
	9	3.2	116	3.4	115	4.4	93	4.3	118	2.2	155	4.2	107
	5	4.3	102	4.0	106	5.0	134	5.2	97	2.6	145	4.9	98
Wethers	1	3.2	115	2.4	131	3.3	110	3.5	127	1.8	148	3.6	112
	7	3.2	123	2.8	126	3.8	103	3.9	124	2.1	148	3.8	111
	3	3.3	118	2.9	124	3.8	107	4.0	122	2.1	148	3.9	112
	9	3.5	118	3.2	121	4.2	100	4.5	116	2.4	148	4.2	105
	5	3.9	107	3.8	108	4.7	103	5.0	122	2.7	145	4.6	90
	X	2.7	134	2.4	138	3.2	115	3.2	140	1.9	150	3.3	117

Note: Wethers 1's, South Island only.
5's, North Island only.

Between joints, the loin, thorax and pelvis are closely similar with the highest calorie value and lowest protein value. The neck, shoulders and legs follow in that order, with the legs again being outstanding in their high protein but low calorie content per kilogram.

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THE COMPOSITION OF NEW ZEALAND CHEDDAR CHEESE

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(*Received for publication, 25 July 1950*)

Summary

An analysis has been made of the average composition of cheese in the nine main grading-store districts in New Zealand over the dairying seasons 1943-45.

Moisture content of cheese (at 14-21 days after manufacture) in all grading-store districts became lower during the first few months of the dairying season, and thereafter rose steadily until the end of the season. The average moisture content of New Zealand cheese during these years was 34·3 per cent. With allowance of a further 3 per cent loss during ripening, the average moisture content of New Zealand mature cheese may be taken as 31·3 per cent.

Fat content of the cheese remained steady in all districts during the first months of the dairying season, but commenced to rise in November. The rise continued in all districts until February. Thereafter in some districts there was a reduction in fat content with progress of the season. The average fat content of the cheese over the two years was 36·6 per cent. When allowance is made for moisture loss during ripening, the average fat content of mature cheese may be taken as 37·7 per cent.

The monthly average percentage content of water in the fat-free dry substance (W.F-f.S.) of cheese in the nine main grading-store districts ranged from 52·2 to 57·6 per cent. The average overall the cheese during the two years was 54 per cent. Cheese from the Auckland districts had consistently a W.F-f.S. content lower than 54 per cent, while cheese from the other districts had W.F-f.S. values fairly consistently above this value. The reason for the difference is not apparent.

The content of fat in the water-free solids of cheese rose in all districts during the later months of the dairying season. The actual values for percentage F.W-f.S. were higher in the cheese from the Northern districts than in those from the Southern districts. The average percentage F.W-f.S. for New Zealand cheese was 55·7 per cent, compared with the New Zealand legal minimum of 50 per cent, and the British minimum for whole milk cheese of 45 per cent. The lowest monthly average F.W-f.S. for the cheese from any of the districts was 51·6 per cent.

If cheese were standardized to an average F.W-f.S. content of 52·0 per cent, some standardization would be possible in all districts but it would scarcely be economic in the Southern districts. If all New Zealand cheese were standardized to an average of 52 per cent F.W-f.S., it would be necessary to remove approximately 14·0 per cent of the fat in the milk received at the factory. Because of the unavoidable errors in standardization and analysis, however, standardizing to an average of 52 per cent F.W-f.S., would mean allowing the export of Cheese of 51 per cent F.W-f.S., or perhaps even of 50.5 per cent F.W-f.s.

Data are given permitting an examination of the economics of standardization of milk for cheesemaking.

The average percentage fat content of milk supplied to cheese factories in New Zealand increased during the period 1930-1940 ; but since that time it has remained comparatively static. This applies over all the main cheese-making districts except Southland. In Southland the average percentage fat content of cheese factory milk supplies has not undergone any significant change since 1930.

The average yield of cheese per pound of butterfat delivered to cheese factories in New Zealand decreased during the period 1930-40 but has remained comparatively static since that time, in keeping with the trends expected from the data for average fat content of the cheese factory milk supplies.

Introduction

The composition of Cheddar cheese is dependent mainly on the composition of the milk from which it is produced. Milks containing the same proportion of casein to fat (but not necessarily the same percentage fat content) yield, on the average, cheese of the same composition. ((1) p. 253). Milks of high percentage fat content, however, normally have a lower proportion of casein to fat than milks of low fat content, and therefore yield cheese of high fat content, expressed either as a percentage of fat in the cheese, or (to avoid the confusing effects of variations in moisture content of the cheese) as a percentage of fat present in the water-free solids of the cheese. The fat content of milk changes with change in the stage of lactation of the cows in a herd, rising steadily during the last few months of the lactation period. The percentage casein content of the milk increases also with progress of lactation, but the increase is smaller proportionally than the increase in fat content. This leads to a rise in fat content of cheese made from milk drawn in the later stages of lactation.

In New Zealand, where dairying for cheesemaking is almost wholly seasonal, the change in fat content of cheese can be expected to be recurrent each season, and to apply over all the cheesemaking districts. While analyses of New Zealand export cheese have been made by the Dairy Division of the Department of Agriculture regularly during the past 17 years, the figures have not hitherto been collated to the stage of showing either the nature of the variations in cheese composition over the dairying season, or the degree of uniformity in the nature of these changes in the cheese from the different cheesemaking districts.

Source of the Data

The study is based on data extracted from the analysis records for export cheese received at the different grading ports in New Zealand during the period July, 1943 to June, 1945, i.e., over two complete dairying seasons. Owing to unavoidable delay in completing the computations, the results as presented may seem somewhat out of date. They represent, however, the only suitable two-year period for the study in the decade 1939-1949: (a) in the years 1941-43 the cheese production in New Zealand was greatly increased, since at that time cheese was regarded as a more important product than butter in the planning of food supplies during the war emergency (at the close of the year 1942-1943 the normal partition between cheese and butter manufactured was resumed); (b) the year 1945-1946 was abnormal in the Auckland districts because of a prolonged and severe drought in the autumn months; and (c) the year 1947-1948 was abnormal in the Taranaki, Wanganui and Wellington districts, for a similar reason.

The average fat content of the milk received at cheese factories has not greatly changed since 1945. The figures, therefore, with changes to suit changes in the volume of cheese production, are applicable with sufficient accuracy to present-day conditions. These records do not cover the whole of New Zealand's cheese production, as they do not include a portion of the cheese sold for local consumption. Since, however, the average annual amount consumed locally during these years was only 8,500 tons*, or 8·8 per cent of the total production, viz.,

* This quantity was higher than the normal quantity of cheese consumed locally, because of the presence of United States armed forces in New Zealand during these years.

96,882 tons, and since a portion of the cheese consumed locally was withdrawn from the export stores after it had been analysed, it may be accepted that the figures presented represent sufficiently accurately the average composition for the whole cheese production for the years under review.

The analyses of the cheese for moisture and fat content were made on composite samples of each shipment received at each grading-store. A sample of constant size was taken from each trier-plug of cheese drawn for grading purposes from a shipment (in the grading of cheese in New Zealand a plug is drawn from a cheese from every vat represented in the shipment). The samples were passed through a grater, and the resulting finely divided sample was well mixed in an airtight bottle before portions were withdrawn for analysis. The moisture content was estimated by the oven method at a temperature of 102-103°c. over a period of 15 hours[2], and the fat content was estimated by the Babcock method. It will be noted that the method of sampling implies that the weight of cheese from each vat was constant ; while this assumption is not correct, it is sufficiently so for all practical purposes.

As a routine operation in the keeping of records in the separate grading-stores, the results for percentage fat content of the cheese are related to the weight of cheese in each shipment, and a schedule is prepared showing both the weight of cheese made each month at each factory in the district and the weight of fat in the cheese from each factory each month. These figures were kindly made available by the Department of Agriculture for the present study.

Factors Influencing Composition of Cheese

The composition of cheese is influenced by some factors other than the composition of the original milk. These factors, which are concerned both with conditions of manufacture of the cheese and with conditions of its storage during ripening, may be summarized as follows (for full discussion, see McDowall[1] :

(i) variation in extent of loss of fat in the whey ;

(ii) variation in extent of loss of casein in the whey ;

(iii) variation in the rate of salting of the cheese ;

(iv) variation in the extent of moisture expulsion during manufacture as controlled by (a) cooking temperature, (b) acidity-production in the curd by the starter bacteria, (c) curd-draining conditions, and (d) rate of salting ;

(v) time and conditions of holding in the curing-room, and conditions of transport of the cheese to the grading store, before the cheese is analysed.

When the composition of cheese is quoted as a percentage based on the weight of cheese, all the above factors have an influence on the final figure. When the composition is quoted as a percentage of the quantity of water-free solids in the cheese, only factors (i), (ii) and (iii) have any very significant influence on the results obtained. In the present paper the composition of New Zealand cheese is discussed from both these points of view.

The effect of factor (v), viz., period of holding after manufacture and conditions of holding during this period, was subject to some variation during both seasons. The cheese were analysed after three weeks' holding in the curing-room from August to September, inclusive, and

after two weeks from October to July, inclusive. The longer period of holding thus coincided with the period of colder temperatures. But even in any district subject to the same atmospheric temperature conditions, variations in extent of moisture loss during the 2-3 weeks' holding period in the factory would occur, resulting from variations in the efficiency of the installation, or in the system of ventilation of cheese-curing rooms, e.g., installation of artificial temperature and humidity control apparatus in some of the curing-rooms. Similarly, cheese from a factory close to the grading-store is transferred more quickly from factory to store than cheese from a distant factory. No attempt has been made to define the influence of these variable conditions of holding and transport on the figures quoted below.

DESCRIPTION OF DATA AVAILABLE FROM GRADING-STORE RECORDS

There were nine grading-store districts of major importance. The number of factories, the average annual production of cheese per factory, and the range of factory size in each district, are given in Table I.

Data for the cheese production for each factory over each month of the year, grouped according to the district served by the grading-store, were available as follows :

A. Weighted average fat content of the cheese for the month.

B. Weighted average moisture content of the cheese for the month.

C. Total weight of cheese for the month.

In the utilization of these figures it has been assumed that the straight arithmetical averages of the weighted monthly average percentage fat and moisture contents of the cheese from each factory in a district can be taken to represent the weighted averages for all cheese from the district. This assumption would only be exactly valid if the same weight of cheese were produced at each factory each month. As shown in Table I, the monthly cheese production per factory varies considerably;

TABLE I. NUMBERS AND SIZES (ANNUAL CHEESE PRODUCTION, AVERAGE FOR TWO YEARS 1943-44 AND 1944-45) OF FACTORIES IN THE NINE GRADING STORE DISTRICTS OVER THE YEARS 1943-45.

Grading-Store District	Number of factories		Annual Production of Cheese per Factory (tons)		
	1943-44	1944-45	Average	Minimum	Maximum
Auckland *	15	14	514	105	976
N.Z. Co-op. Dairy Coy *	25	25	616	226	1293
New Plymouth	48	47	394	85	1279
Patea	45	45	487	9	1189
Wanganui	9	9	262	80	590
Wellington	49	48	241	20	832
Lyttelton	11	12	141	12	314
Dunedin	14	13	86	7	228
Invercargill	52	50	169	6	640

* Cheese for the two "districts", Auckland and New Zealand Co-operative Dairy Coy are graded at the Auckland Grading Store. Since, however, the N.Z. Co-op. Dairy Coy supplies cheese from 25 factories, these are grouped separately in the Auckland grading-store records. This separate grouping is retained in the present study.

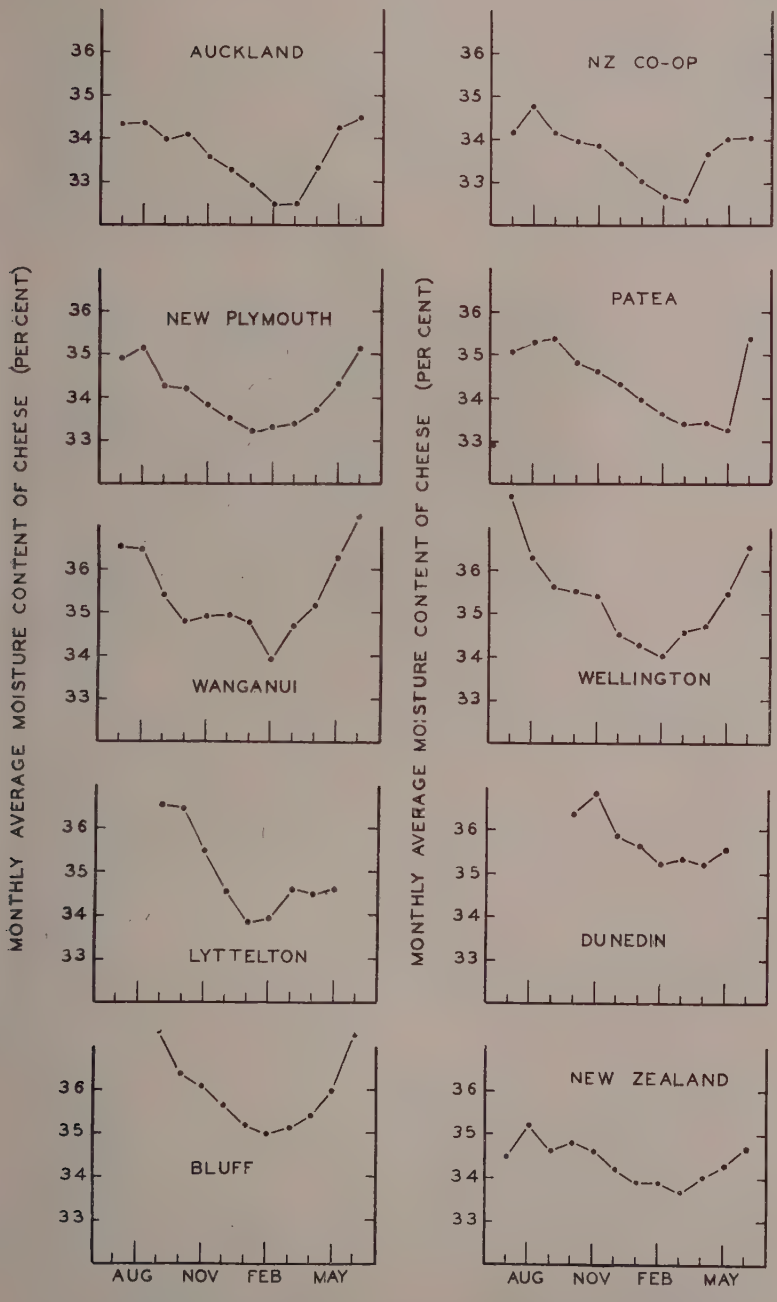

Fig. 1.—Monthly average moisture contents of cheese received into the main New Zealand grading stores, and for the cheese received into all these stores combined, during the dairying seasons 1943-45 (see Table 11).

but, since the variation in composition of the cheese from factory to factory in a district was usually not large, and since the number of factories in most of the districts was large, the possible errors of taking the arithmetical instead of the weighted average may be neglected. The average composition of the cheese and the quantity of cheese produced annually varied widely from district to district, as shown in Table I. In the computation of the monthly New Zealand averages and of the annual averages, therefore, account has been taken of both weight and composition of the cheese from the separate districts.

AVERAGE MOISTURE CONTENT OF CHEESE AS RECEIVED AT THE GRADING-STORES IN NEW ZEALAND

The averages are shown in Fig. 1. There was a decrease in moisture content of the cheese during the first months of the season. The minimum was reached in all districts in February. Thereafter until the end of the season there was a steady and fairly consistent rise in moisture content. The weighted average moisture content of the cheese (at 2-3 weeks after manufacture) from all districts for each month is given in Table II. The New Zealand weighted average was 34·3 per cent.

TABLE II. WEIGHTED MONTHLY AVERAGE PERCENTAGE COMPOSITION OF NEW ZEALAND CHEESE OVER THE DAIRYING SEASONS 1943-45

Month of Year	Moisture Content (%)	Fat Content (%)	Water in fat-free Solids (%)	Fat in Water-free Solids (%)
July	34.5	36.2	54.1	55.3
August	35.2	35.8	54.7	55.2
September	34.6	36.4	54.5	55.7
October	34.8	35.7	54.1	54.8
November	34.6	35.8	53.9	54.8
December	34.2	36.6	53.9	55.6
January	33.9	37.2	54.0	56.5
February	33.9	37.6	54.3	56.8
March	33.7	37.6	54.0	56.8
April	34.0	37.4	54.3	56.7
May	34.3	37.4	54.9	57.0
June	34.7	36.6	54.7	56.0
July-June (New Zealand figure).	34.3	36.6	54.04	55.71

AVERAGE FAT CONTENT OF CHEESE AS RECEIVED AT THE GRADING-STORES IN NEW ZEALAND

The averages for the separate grading-store districts are shown in Fig. 2. The fat content of the cheese remained relatively steady during the first months of the dairying season in all districts, but commenced to rise in November. The rise continued until February. Thereafter, in most districts this was followed by a decline which continued until May. In some districts the fat content of the cheese fell to approximately the same level as at the beginning of the season. This may be taken both as a direct (arithmetical) result of the rise in moisture content of the cheese (see Fig. 1) and as an indication of change in milk composition (see Fig. 3). The lines in Fig. 3 show the monthly average fat test of the milk from cows in the Dominion Group Herd Test Groups

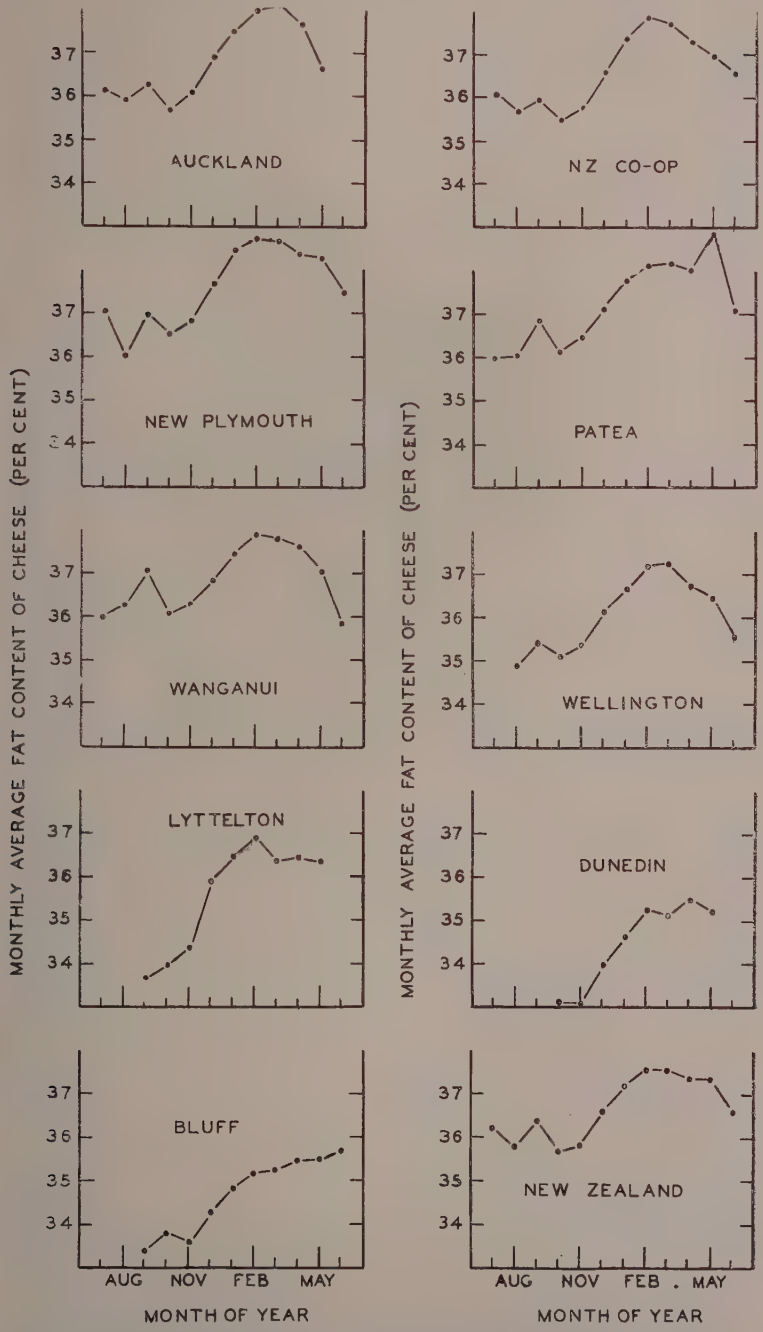

Fig. 2.—Monthly average fat contents of cheese received into the main New Zealand Grading Stores, and for the cheese received into all these stores combined, during the dairying seasons 1943-45 (see Table III).

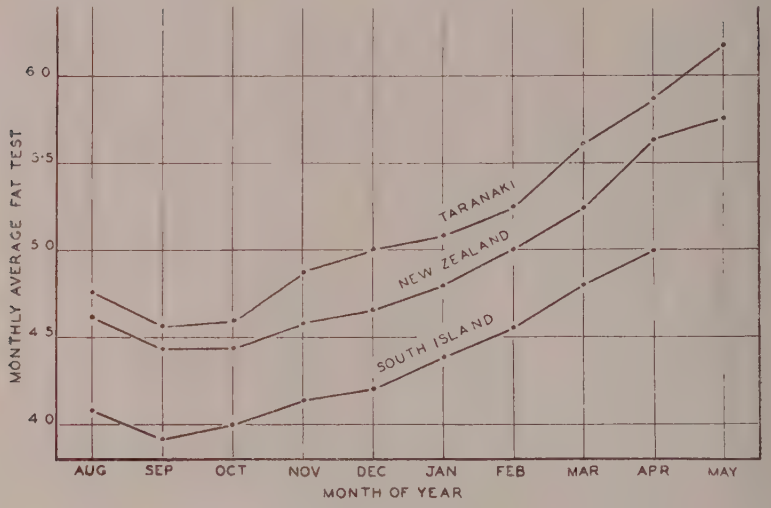

FIG. 3.—Average monthly fat test of milks tested by Group Herd Testing Associations during 1943-45.

for the whole Dominion and indicate a normal change over the dairying season. They do not represent a true lactational curve, as they are not corrected for variations in calving dates of the cows in the herds tested.

The weighted average fat content of the cheese from all districts for each month is given in Table II. The New Zealand weighted average was 36·6 per cent.

AVERAGE PERCENTAGE CONTENT OF WATER IN THE FAT-FREE SUBSTANCE (W.F-f.S.) OF CHEESE AS RECEIVED AT THE SEPARATE GRADING-STORES IN NEW ZEALAND

Moisture is carried into, and is retained in, cheese mainly by the renneted casein. Veale[3] has pointed out, and McDowall[1] has presented supporting evidence, that in normal cheese at 14 days after manufacture the content of water in the fat-free substance is of the order of 54-55 per cent. The results shown in Fig. 4 support this generalization. The weighted average percentage W.F-f.S. in the cheese from all nine districts for each month is given in Table II. The New Zealand weighted average was 54·04 per cent. It is evident from Fig. 4, however, that there were (a) district variations, and (b) some seasonal variations, in percentage W.F-f.S. in the cheese.

(a) *District Variations.* The cheese from Auckland district (Auckland and N.Z. Co-op. groupings) contained consistently less than, and the cheese from all the other districts contained consistently more than, 54 per cent. of fat in the water-free substance. The reason for this difference is not apparent, but it is known that cheesemaking procedure found satisfactory in the New Plymouth, Patea and Wellington districts cannot be successfully applied in full detail in the Auckland district (Whitehead[4]). The practice of draining the whey at low acidities, common in Southern districts when single strain starters are used, yields " sweet " cheese in the Auckland district. Dolby[5] has suggested

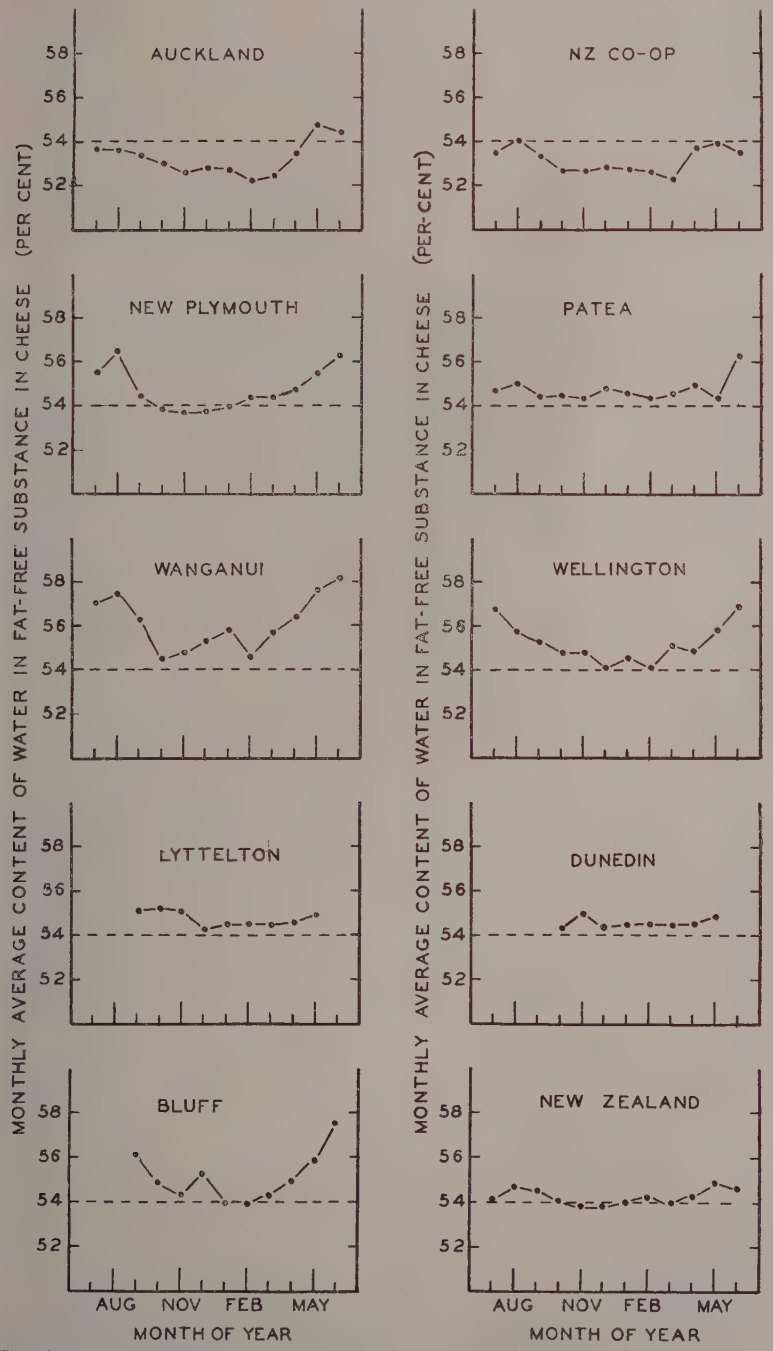

Fig. 4.—Monthly average content of water in the fat-free substance of cheese received into the main New Zealand Grading Stores, and for the cheese received into all these stores combined, during the dairying seasons 1943-45 (see Table IV).

that a difference in the proportion of bound water held by the casein, by influencing the tendency of the cheese curd to retain moisture, could explain the difference in cheesemaking properties of the milk from the two districts, but his measurements of bound water in the milk and cheese curd from the different districts did not reveal any significant differences. Whatever the cause (unless it be connected with differences in the system and conditions of collection of samples for analysis, or of carrying out the analyses), the differences illustrated in Fig. 4 are of interest to a study of the fundamental chemistry and bacteriology of cheesemaking.

(b) *Seasonal Variations.* In most districts the percentage W.F-f.S. was higher at the beginning and end of the season than during the intermediate period. This may have been due only to the warmer conditions of holding the cheese during this intermediate period, or it may have been caused in part by changes in the water-holding capacity of the cheese curd. It is known that cheesemaking conditions must be varied to suit the changes in the properties of cheese milk with progress of the lactation period.

AVERAGE PERCENTAGE CONTENT OF FAT IN THE WATER-FREE SOLIDS (F.W-f.S.) OF CHEESE AS RECEIVED AT THE SEPARATE GRADING-STORES IN NEW ZEALAND

For simple arithmetical reasons the percentage fat content of cheese from any one milk varies inversely with the percentage moisture content. Since moisture content of cheese varies with the conditions of manufacture and with the length of the ripening period and the conditions of storage, the citation of fat content in terms of the cheese as sampled has the disadvantage that the figures cannot be accurately related to the composition of the milk from which the cheese was made. Official Regulations governing cheese composition usually specify a minimum *percentage content of fat in the water-free substance of the cheese.* This figure remains fairly constant during the whole ripening period, and it is independent of the moisture content, although some slight changes occur due to evolution of carbon dioxide and, possibly, other gases from the cheese during ripening. The requirements of the Regulations in New Zealand are that whole-milk cheese shall contain not less than 50 per cent fat in the water-free substance. In United Kingdom the generally accepted minimum is 45 per cent. In Holland full-fat cheese must contain 45 per cent F.W-f.S., but standardized cheese containing 40, 30 and 20 per cent F.W-f.S. may be manufactured provided they are labelled accordingly. Manufacture of standardized cheese, at the time of writing (July, 1950), is not permitted in New Zealand, except on an experimental basis.

The monthly average values for percentage F.W-f.S. in the cheese in the nine cheesemaking districts are shown in Fig. 5.

(a) *District Variations.* The percentage F.W-f.S. in the cheese was higher in the northern districts, where the cows are predominantly of the Jersey breed, than in the southern district, where there is a considerable proportion of the lower-testing breeds (see Fig. 3). The weighted average percentage F.W-f.S. in the cheese from all districts for each month is given in Table II.

(b) *Seasonal Variations.* There was consistently in all districts a rise in the F.W-f.S. value towards the end of the season, in keeping with a rise in fat content and with the fall in casein/fat ratio in milk

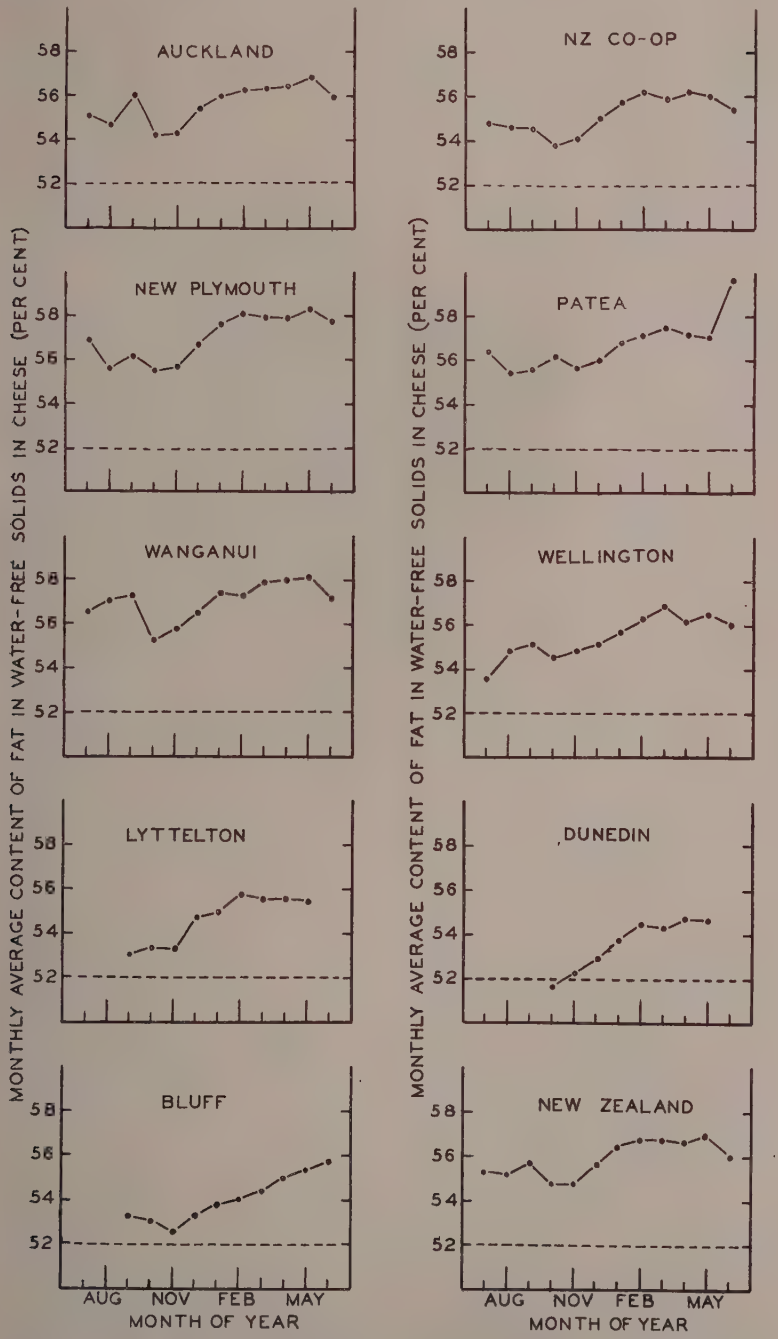

FIG. 5.—Monthly average content of fat in the water-free substance of cheese received into the main New Zealand Grading Stores, and for the cheese received into all these stores combined, during the dairying seasons 1943-45 (see Table V)

from cows in the later stages of lactation. The fall in percentage fat content of cheese towards the end of the season in some districts (see Fig. 2) was caused by the rise in percentage moisture content at this time (see Fig. 1) and was not a true reflection of the changes occurring in the composition of the milk.

Relation of actual F.W-f.S. Values to Legal Minimum Values

It is clear from Fig. 4 that the percentage of fat in the water-free substance of New Zealand cheese is much higher that the minimum set by the New Zealand Regulations, which, as we have seen, is 5 per cent higher than that accepted in Great Britain. The weighted average for the whole of the New Zealand cheese production (see Table II) was 55·71 per cent. While cheese is primarily a protein food, the butterfat is the constituent most commercially valuable. For this reason New Zealand cheese with its high fat content has been used by processed cheese manufacturers for blending with cheaper skim milk cheese to yield a final processed cheese with F.W-f.S. content still above the minimum required by the Regulations.

Minimum monthly average percentage F.W-f.S.

The minimum monthly average values for percentage F.W-f.S. in the cheese received at the different grading-stores are given in Table III.

TABLE III. MINIMUM MONTHLY PERCENTAGE F.W.-f.S. IN CHEESE RECEIVED AT SEPARATE GRADING STORES

Grading Store	% F.W.-f.S.
Auckland (independent factories)	54.2
N.Z. Co-op. Dairy Co.	53.8
New Plymouth	55.5
Patea	55.4
Wanganui	55.3
Wellington	53.8
Lyttelton	53.1
Dunedin	51.6
Bluff	52.6

The monthly average was only once below 52·0 per cent. While the monthly average for cheese at some individual factories, and also cheese from single vats at many factories, would no doubt show lower values than 51·6 for percentage F.W-f.S., it is evident that New Zealand cheese is consistently of much higher fat content than is required by the Dairy Produce Regulations or by the Food and Drug Regulations.

COMPARISON OF AVERAGE PERCENTAGE COMPOSITION OF CHEESE AS RECEIVED AT THE SEPARATE GRADING PORTS

The average percentage fat and moisture contents of cheese as received at the separate grading-stores was computed from the figures for total weight of cheese received and total weights of fat and moisture in these cheese, and the values for average W.F-f.S. and F.W-f.S. were computed from these results. The averages for the separate grading-store districts and for the whole of New Zealand are given in Table IV and in Fig. 6

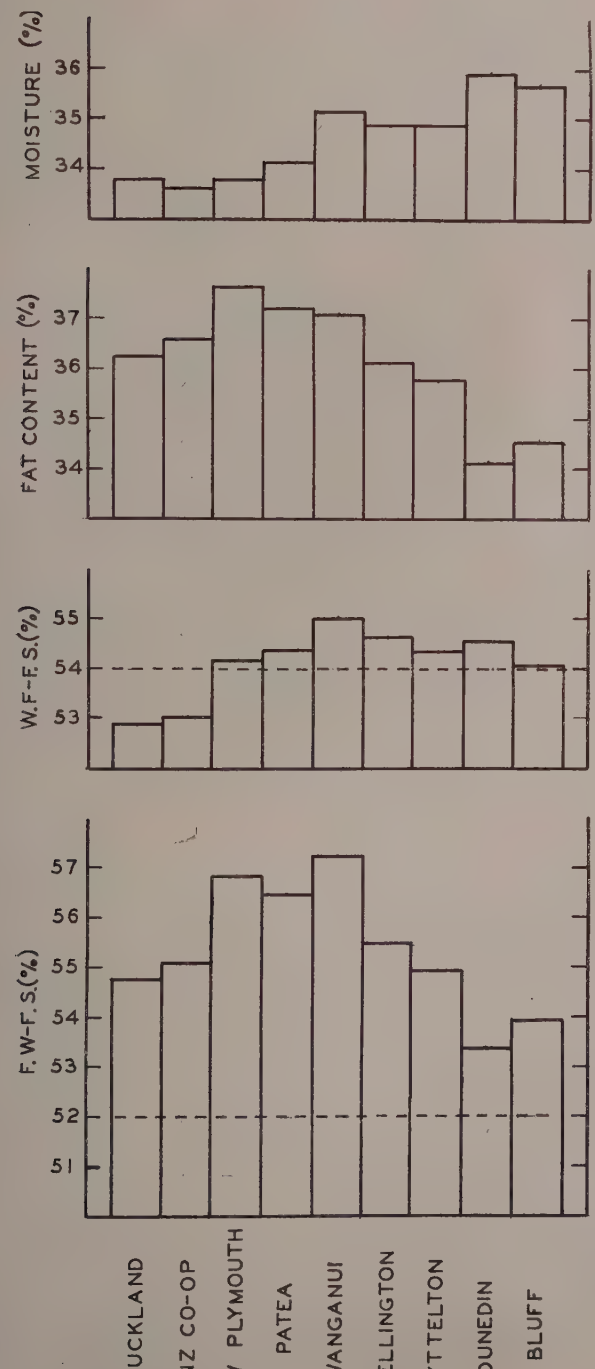

Fig. 6.—Direct comparison of average annual composition of New Zealand cheese received into the main Grading Stores during the dairying seasons 1943-45 (see Table VII).

TABLE IV. AVERAGE COMPOSITION OF CHEESE RECEIVED AT THE SEPARATE GRADING-STORES, AND AT THE STORES COMBINED, OVER THE DAIRYING SEASONS 1943-45

Grading-Store District	Average Moisture Content (%)	Average fat Content (%)	Average W.F-f.S. (%)	Average F.W-f.S. (%)
Auckland	33.8	36.3	52.9	54.8
N.Z. Co-op.	33.6	36.6	53.0	55.1
New Plymouth	33.8	37.6	54.2	56.8
Patea	34.2	37.2	54.4	56.5
Wanganui	35.2	37.1	55.1	57.3
Wellington	34.9	36.1	54.6	55.5
Lyttleton	34.9	35.8	54.3	55.0
Dunedin	35.9	34.1	54.5	53.4
Bluff	35.7	34.5	54.5	54.0
New Zealand Average	34.3	36.6	54.1	55.7

Cheese containing 34·3 per cent of moisture and 36·6 per cent of fat would contain $100 - (34 \cdot 3 + 36 \cdot 6) = 29 \cdot 1$ per cent of solids-other-than-fat. Of this latter percentage approximately 1·5 per cent would be salt, and 2-3 per cent would be other mineral constituents, lactic acid, and similar substances. The protein content would thus be of the order of 24-25 per cent. During the ripening period approximately 3 per cent of the water would be lost. The approximate average composition of New Zealand mature cheese would then be :

Moisture	31·3	per cent
Fat	37·7	,,
Protein	25·0	,,
Other constituents	6·0	,,

QUANTITATIVE STUDY OF STANDARDIZATION OF MILK FOR CHEESEMAKING

As stated above, standardization of milk for cheesemaking is permitted in most cheesemaking countries. In New Zealand standardization was introduced during the season 1929-1930, but the Regulation permitting standardization was withdrawn in 1930 and has not since been introduced. The reasons for the withdrawal were various. Although it has been demonstrated that, with use of the correct technique, standardized cheese containing 50-52 per cent F.W-f.S. can be made of equal quality to whole milk cheese containing 56-57 per cent F.W-f.S., the differences in manufacturing technique required were at that time not accurately defined. There was, therefore, a fall in cheese quality coincident with the introduction of standardization.

Because of the high fat content of New Zealand cheese and of the tendency towards increase in average fat content of milk expected to result from current herd-improvements schemes, the pros and cons for the re-introduction of standardization of milk for cheesemaking in New Zealand have been under discussion. Full study of this question involves consideration of matters of general industry policy which are outside the scope of this paper. Any discussion of the subject from the policy viewpoint, however, should have as a background the quantitative data showing the effect of standardization on quantity of cheese produced ;

and without such information an evaluation of the economics of standardization is not possible. The following quantitative analysis is presented with the object of supplying this basic information. It should not be interpreted as an advocacy of the re-introduction of standardization into New Zealand cheesemaking practice.

Calculation of quantity of fat recoverable from New Zealand milk in the manufacture of standardized cheese

Method of Calculation

The calculation was made as in the following example :—

Let whole milk cheese contain 56 per cent F.W-f.S., i.e., 56 parts of fat are present in 100 parts of solid matter of cheese.

Let X = amount of fat to be removed from 100 parts of solid matter of cheese to give a final cheese of 52 per cent F.W-f.S.

$$\text{Then } \frac{56 - x}{100 - x} = \frac{52}{100}$$

$$5600 - 100x = 5200 - 52x$$

$$48x = 400$$

$$x = 400/48 = 8{\cdot}33 \text{ per cent.}$$

The general formula thus is :—

$$\left.\begin{array}{l}\text{Amount of fat to be recovered} \\ \text{from 100 parts of W f.S. in} \\ \text{cheese}\end{array}\right\} = \frac{(\text{actual F.W-f.S.} - \text{desired F.W-f.S.}) \times 100}{100 - \text{desired F.W-f.S.}} \quad \text{(A)}$$

Applying this formula in the above example we have :

$$\left.\begin{array}{l}\text{Amount of fat to be recovered} \\ \text{from 100 parts of W-f.S. in} \\ \text{the cheese}\end{array}\right\} = \frac{56 - 52}{100 - 52} \times 100 = \frac{400}{48}$$

The calculation was then made in the following sequence for the cheese received each month at all grading-store districts over the two years.

$$\frac{\text{Wt. fat to be removed per 100 parts of W-f.S. in cheese}}{\text{Wt. fat in 100 parts of W-f.S. in cheese}} \times 100 = \text{percentage of fat removable.}$$

$$i.e.\ \frac{A}{\%\ \text{F.W-f.S.}} \times 100 = \text{percentage of fat removable (B)}$$

$$\frac{\text{Wt. Cheese} \times \%\ \text{W-f.S.}}{100} = \text{Wt. W-f.S. in cheese (C)}$$

$$\text{Wt. W-f.S. in cheese} \times \frac{\%\ \text{W-f.S. removable, } i.e., C \times \frac{A}{100}}{100} = \text{Wt. of fat removable.}$$

$$\frac{\text{Total wt. of fat removable from cheese in each district}}{\text{Total wt. of fat in cheese for each district.}} \times 100 = \text{Percentage of fat removable over the whole period.*}$$

Results of Computation

Standardization of milk for cheesemaking can never be very accurate [6,7], and tolerance must be allowed for errors of analysis. If the F.W-f.S. values in individual cheese are not to fall below 50 per cent,

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* The method of computation used was not exactly correct, since the fat is not removable from the milk used for cheesemaking without removal also of some casein in the cream. This removal of casein would influence the composition of the resultant cheese, and a further quantity of fat would be removable in proportion to the amount of casein removed. Allowance for this would greatly have complicated the calculations. Since the effect for the final result would not be large, this complication was omitted. The results presented in Tables V and VI thus are conservative estimates of the amount of fat removable in standardization.

TABLE V. MONTHLY PERCENTAGE OF FAT IN MILK DELIVERED TO CHEESE FACTORIES IN NEW ZEALAND IN 1943-45 REMOVABLE TO GIVE AN AVERAGE OF 52 PER CENT FAT IN THE WATER-FREE SOLIDS OF CHEESE

Grading-Store	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Auckland	11.6	10.4	11.3	8.3	8.8	12.5	14.8	15.7	16.1	16.6	18.0	14.5
N.Z. Co-op.	10.6	10.0	9.7	6.8	7.9	11.3	14.0	15.6	14.5	15.6	14.8	12.8
New Plymouth	17.8	13.3	15.7	13.2	13.8	17.2	20.1	21.7	21.7	21.2	22.5	20.6
Patea	12.5	13.6	15.3	12.9	13.9	16.8	19.0	19.8	19.4	18.6	22.3	19.6
Wanganui	16.9	18.9	19.5	12.6	14.1	16.9	19.6	19.4	21.1	21.6	21.8	18.6
Wellington	15.6	10.8	11.7	9.4	10.7	12.2	13.9	16.0	18.0	15.1	16.6	15.2
Lyttelton	-	-	4.2	5.7	4.9	10.7	11.5	14.3	13.4	13.4	13.3	-
Dunedin	-	-	-	-	2.6	3.5	7.0	9.4	8.9	10.6	10.3	-
Bluff	-	-	4.9	4.3	2.4	5.1	6.8	8.1	9.2	11.2	12.8	13.9
New Zealand Average	12.4	12.3	13.1	10.1	10.5	13.4	15.6	17.0	17.3	17.2	18.0	14.2

the average must be well above the minimum value. For normal practice in standardization, an average of 52·0 per cent F.W-f.S. in the cheese would appear to give a reasonably safe margin. The percentages of fat removable from the milk to give this average of 52 per cent F.W-f.S. in the cheese are given in Table V and in Fig. 7.

It was already evident from the relationship of the lines in Figs. 3 and 5 to the dotted lines representing 52 per cent F.W-f.S. in the cheese that, on the average, some standardization of cheese would have been possible in most New Zealand districts throughout the season, and in all New Zealand districts through part of the season. For all districts, however, there may have been some individual factories with low-testing milk, or with low-testing vats of milk, which could not be standardized. In New Plymouth and Patea districts the proportion of fat removable to give cheese of 52 per cent average F.W-f.S. during the later stages of the season would have been more than 20 per cent of the total amount of fat in the milk.

Effect of Variation in the Average Percentage F.W-f.S. Content Desired on the Amount of Fat Removable

The percentage of fat removable from the cheese in each cheesemaking district, to give average values for percentage F.W-f.S. in cheese of 50, 51 and 53 per cent, are given in Table VI. Even with the 53 per cent F.W-f.S. average, some fat would have been removable from the cheese in all districts, although the proportion removable in some districts would have been so small that the introduction of standardization would not have been economically worthwhile.

TABLE VI. PROPORTION OF FAT REMOVABLE FROM NEW ZEALAND CHEESE MILK OVER THE YEARS 1943-45, TO GIVE DIFFERENT FINAL AVERAGE VALUES FOR PERCENTAGE FAT IN THE WATER-FREE SOLIDS OF THE CHEESE

Grading-Store	Percentage Fat Removal from Cheese Milk to give Cheese of percentage F.W-f.S. of			
	50	51	52	53
Auckland	19.6	16.3	12.9	9.3
N.Z. Co-op.	18.5	15.2	11.7	8.1
New Plymouth	24.0	20.9	17.7	14.3
Patea	23.0	19.9	16.6	13.2
Wanganui	24.0	20.9	17.6	14.3
Wellington	19.9	16.6	13.2	9.6
Lyttelton	16.9	13.5	13.5	6.4
Dunedin	12.2	8.6	5.1	7.4
Invercargill	13.7	10.3	6.6	3.0

Economics of Standardization of Milk for Cheesemaking

Standardization of milk for cheesemaking involves extra costs for equipment, e.g., for separators and standardizing-vats, and extra costs for operating the standardizing equipment. There is also extra cost involved in the necessarily more frequent analysis of the cheese. In addition, some casein is removed in the cream separated, and this results in a reduction in the yield of cheese obtained. When cream is sold to a butter factory, the cheese factory would receive no compensation for this casein, which in the absence of standardization could

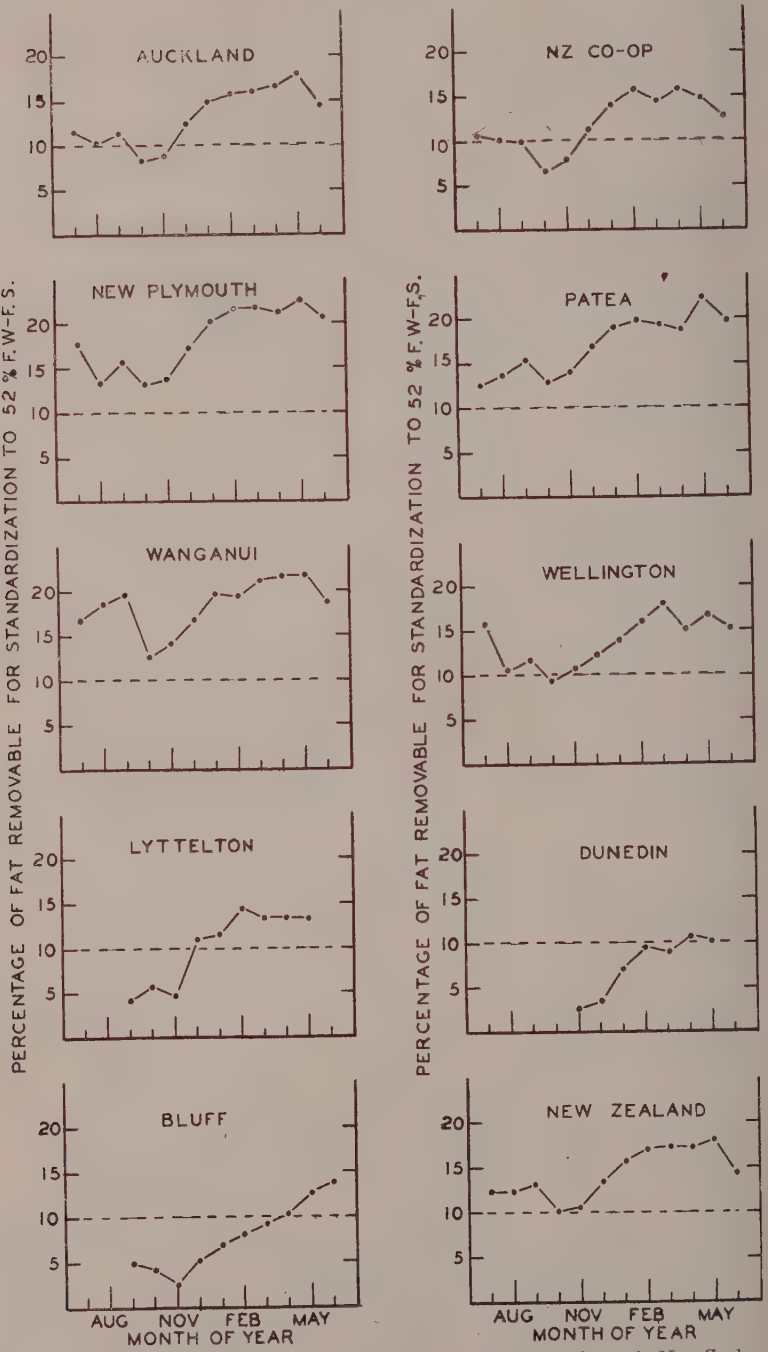

FIG. 7.—Proportion of fat in New Zealand cheese received into the main New Zealand grading ports, and in all the cheese received into these ports combined, in excess of the requirements to give cheese containing on the average 52 per cent of fat in the water-free substance.

have been converted to cheese. The only source of increased return to the cheese factory from standardization is the greater price received for butterfat in butter as compared with the price received for butterfat in cheese. The increased return for the fat removed from the cheese milk and converted to butter must be balanced up against the reduced yield of cheese in the cheese factory resulting from removal of both fat and casein in the cream.

Quantity of Butter made from Cream removed during Standardization

This may be computed from the quantity of fat removed, on an assumed overrun of 20 per cent. The average annual quantities of butter which on this basis could have been manufactured from the cream removed during standardization in the separate cheesemaking districts, and in all districts combined, are shown in Table VII. For an average percentage F.W-f.S. of 52, the butter made from the cream removed would have been approximately 6,000 tons.

TABLE VII. AVERAGE ANNUAL QUANTITIES OF BUTTER WHICH WOULD HAVE BEEN MADE FROM CREAM REMOVED, IF MILK AT ALL CHEESE FACTORIES DURING THE 1943-45 SEASONS HAD BEEN STANDARDIZED TO GIVE CHEESE OF AVERAGE PERCENTAGE F.W-f.S. OF 50, 51, 52 AND 53.

Grading-Store	Extra Weight of Butter made if Fat removed to give percentage F.W-f.S. in Cheese of			
	50	51	52	53
Auckland	830	725	415	300
N.Z. Co-op.	1,359	1,114	659	597
New Plymouth	2,176	1,845	1,602	1,298
Patea	2.381	2,056	1,717	1,364
Wanganui	281	245	207	167
Wellington	1,127	983	781	571
Lyttelton	150	120	89	57
Dunedin	73	52	31	14
Bluff	558	415	267	144
Totals	8,784	7,204	5,966	4,488

Reduction in Cheese Production

(a) *Amount of fat removed.* As an average over the two years for a 52 per cent average F.W-f.S., this would have been 4,895 tons per year.

(b) *Amount of cheese represented by the casein in the cream removed.* Cream of 50 per cent fat content and containing 4,895 tons of fat would contain 4,895 tons of skim milk. The quantity of cheese represented by this skim milk can only be assessed approximately, but would be of the order of 270 tons (removal of skim milk containing 2·70 per cent of casein would be equivalent to a reduction in yield of cheese equivalent to about 5·5 per cent of the weight of milk removed).
The position may then be summarized as follows :—

4,895 tons of fat removed in the cream.

The equivalent of 270 tons of cheese in the skim milk removed with the cream.

Total reduction in cheese yield 4,895 + 270 = 5,165 tons.

The effect of standardization to an average F.W-f.S. of 52 per cent on gross financial return to the cheese industry can be calculated according to the following formula, for the cheese and butter prices obtaining at the time, on the assumption that the 1943-1945 figures for production and cheese composition and the 1951-52 guaranteed prices for New Zealand butter and cheese apply :

Gain :	5,966 tons of butter at £287 10 0 per ton	= £1,715,225
Loss :	5,165 tons of cheese at £158 13 0 per ton	= £ 819,427
	Gross gain through standardization	= £ 896,798

The nett financial gain would be considerably below the gross gain because allowances must be made for :

(a) Costs of manufacture of the butter, although against this the lower costs of cheese manufacture resulting from the reduction in quantity of cheese made, could be set ; and

(b) Extra costs of equipment, labour, cheese analyses, and loss of cheese through extra sampling.

FAT CONTENT OF MILK SUPPLIED TO CHEESE FACTORIES

Payment to suppliers in both butter and cheese factories in New Zealand is made on the basis of quantity of butterfat delivered. This provides an incentive towards increase in butterfat yield per cow ; and since, within a breed, cows with the highest average annual butterfat test have been found, on the average, to yield the largest amount of butterfat annually[8], payment on a butterfat basis tends to induce an increase in average annual butterfat test of the milk. When milk is separated for supply of cream for butter manufacture, high fat test in the milk does not introduce complications, but when milk is supplied for cheese manufacture the higher test in the milk leads to a lower yield of cheese per pound of fat and, therefore, to a lower rate of payout per pound of fat. This places the cheese factory in a disadvantageous position as compared with a butter factory, despite the fact that, on the average within a breed, the high-testing cow yields in her milk more " potential cheese " per year than the low-testing cow (McDowall[8]).

While it is necessary, in a consideration of the question of introducing standardization of milk for cheesemaking, to study the economic advantages and other factors connected with general policy within the industry, some account must also be taken of likely future trends. These trends may be influenced by the recent attempts to increase the range of proven sires available for breeding purposes, both by increasing their number and by use of artificial insemination. While it is outside the scope of this paper to attempt any forecast of the extent to which these practices will affect the average butterfat content of milk supplied to cheese factories, some data showing the changes that have occurred during the past 20 years are of direct interest to the subject under discussion.

It is evident from Table VIII and Fig. 8 that, over the period 1930-1940 there was a steady rise in average fat test of milk supplied to cheese factories ; but after 1940 the annual average fat test of this milk has not undergone any significant change. The Dominion average fat test for the milk from cows submitted for Group Herd-testing (See

TABLE VIII. AVERAGE COMPOSITION OF MILK SUPPLIED TO CHEESE FACTORIES IN NEW ZEALAND, AND AVERAGE YIELD OF CHEESE PER POUND OF FAT, OVER THE PERIOD 1930-48. ALSO AVERAGE FAT TEST OF MILK TESTED BY GROUP HERD TESTING SYSTEM OVER THE YEARS 1939-48.

Dairying Season	Average Fat Test of Cheese Factory Milk Supplies (%)	Average Annual Yield of Cheese per pound of Butterfat (lb)	Average Fat Test of Group Herd-Tested Milk (%)
1930 - 31	4.12	2.58	-
1931 - 32	4.11	2.55	-
1932 - 33	4.01	2.59	-
1933 - 34	4.18	2.56	-
1934 - 35	4.13	2.55	-
1935 - 36	4.20	2.57	-
1936 - 37	4.25	2.55	-
1937 - 38	4.26	2.52	-
1938 - 39	4.26	2.54	-
1939 - 40	4.30	2.50	4.72
1940 - 41	4.35	2.52	4.79
1941 - 42	4.37	2.54	4.76
1942 - 43	4.33	2.54	4.78
1943 - 44	4.28	2.54	4.81
1944 - 45	4.36	2.55	4.91
1945 - 46	4.34	2.55	4.78
1946 - 47	4.38	2.54	4.84
1947 - 48	4.37	2.51	4.86

TABLE IX. AVERAGE ANNUAL FAT TEST OF MILK DELIVERED TO CHEESE FACTORIES IN THE MAIN CHEESEMAKING DISTRICTS OVER THE PERIOD 1931-32 TO 1946-47.

Year	Average Fat Test of Cheese Factory Milk Supply for			
	Auckland	Taranaki	Wellington	Southland
1931 - 32	4.04	4.34	4.13	4.02
1933 - 34	4.16	4.40	4.21	3.68
1934 - 35	4.08	4.33	4.20	3.63
1935 - 36	4.15	4.40	4.25	3.64
1936 - 37	4.22	4.45	4.31	3.75
1937 - 38	4.25	4.48	4.27	3.65
1938 - 39	4.20	4.51	4.28	3.69
1939 - 40	4.28	4.54	4.28	3.73
1940 - 41	4.32	4.58	4.36	3.71
1941 - 42	4.37	4.57	4.40	3.72
1942 - 43	4.27	4.58	4.33	3.74
1943 - 44	4.26	4.51	4.29	3.70
1944 - 45	4.32	4.58	4.15	
1945 - 46	4.24	4.59	4.38	
1946 - 47	4.28	4.60	4.41	

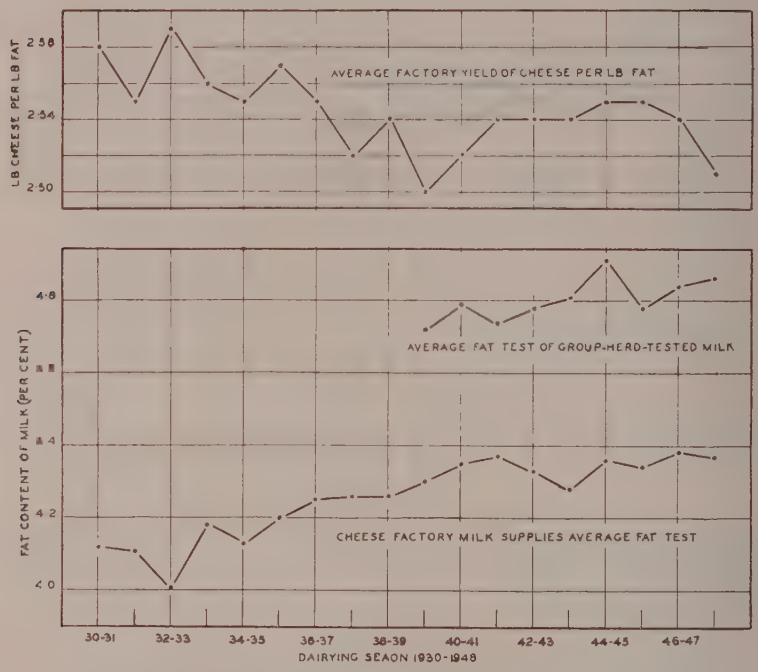

FIG. 8.—Average percentage fat content of cheese factory milk supplies, and average yield of cheese per pound of fat over the years 1930-31 to 1947-48. Also average fat test of milks tested by the New Zealand Group Herd Testing Association for the years 1939-40 to 1947-48.

Table VIII and Fig. 8) has risen slightly during this latter period*. The average Dominion factory yield of cheese per pound of fat, as compiled by the New Zealand Dairy Board from Cheese factory Company balance sheets, are also given in Table VIII and Fig. 8. The yield graph shows the expected trends, viz. a fall during the period when the average fat test of cheese factory milk supplies was rising, and a steady value during the period when the average fat test of the factory milk supplies has remained comparatively stationary. There is then no evidence to indicate that over New Zealand as a whole the difficulties involved in use of high-testing milk for cheesemaking have recently become more acute.

The average annual fat tests of milk delivered to cheese factories in the four main cheesemaking districts are given in Table IX. The figures show that the changes noted for the cheese factory milk supplies, taken as a Dominion average, were evident in all the main North Island cheesemaking districts, viz. a rise in average fat test until 1939-40, but thereafter a relatively stable average test. The fat test of cheese factory milk supplies in Southland remained uniform throughout the whole period 1933-47.

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* The average fat test for the cows under Group Herd Test was much higher than the average for the cheese factory milk supplies, due no doubt partly to the effects of group herd testing in increasing the average fat test of the milk from the cows tested, and in part to the preponderance of diversion of butterfat to buttermaking as compared with cheesemaking.

Although the district and Dominion average percentage fat contents of milk have remained comparatively stable for a number of years, it is possible that there may have been recent changes towards higher average fat test at some individual factories, balanced by changes in the reverse direction at other factories. This possibility has not been examined in detail. It will be noted that the average fat test of cheese factory milk supplies in Taranaki was higher than the corresponding test for Auckland, in keeping with the higher values for percentage F.W-f.S. in the Taranaki cheese as compared with the Auckland cheese (see Figs. 3 and 5).

Acknowledgments

The author desires to thank the Director of the Dairy Division of the Department of Agriculture for permission to use the Grading-Store cheese analysis records, and for facilitating access to these records ; and Mr. A. H. Ward, Director of the New Zealand Dairy Board Herd Improvement Association for supply of data from Group Herd-Testing records.

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LETTUCE MOSAIC*

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Summary

(1) Lettuce-mosaic is shown to be widespread in New Zealand.

(2) Similarity of symptoms, methods of transmission, host range and physical properties identify the causal virus as *Lactuca* virus 1 of Smith (1937).

(3) Symptoms on lettuce are vein clearing, mosaic mottling, necrosis, dwarfing and failure to heart.

(4) Substantial reduction in yield is caused.

(5) The virus is sap transmitted and carried by from six to fifteen per cent of seed from infected plants. Two to three per cent infection occurred in commercial lines of seed.

(6) The aphids *Myzus persicae* Sulz., *Macrosiphum euphorbiae* Thomas., and *Aphis gossypii* Glov., are vectors.

(7) Natural infection occurs in groundsel plants in the field.

(8) The disease has been transmitted experimentally to pea, sweet-pea, endive, aster, cineraria, and marigold.

(9) The virus was still viable at a dilution of 1 in 70, withstood heating for 10 minutes at 54°c but not 55°c, remained infective in extracted sap stored at 23°c for 24 but not 32 hours and did not pass an L1 Pasteur-Chamberland filter.

INTRODUCTION

LETTUCE-MOSAIC was first recorded in New Zealand by Chamberlain (1948) who found the disease to be widespread. He described symptoms on lettuce and demonstrated that the virus was sap transmissible and seed carried. This paper is an account of a further investigation of the virus in the Dominion.

SYMPTOMS ON LETTUCE VARIETIES

Cabbage lettuce varieties (*Lactuca sativa L. var capitata Hort.*)

Imperial 615, 847 and Great Lakes: Plants which are infected by seed transmission develop clearly defined light green areas on the first leaf (Fig. 1) while later leaves often exhibit vein clearing. When infection has been aphid transmitted vein clearing of young leaves is the first symptom to appear. In either case vein clearing is usually accompanied by leaf puckering and pronounced serration of leaf margins. Vein clearing may later be replaced by a blotchy mosaic pattern (Fig. 2) which is especially noticeable on leaves of flower stalks (Fig. 3). Necrotic spotting of leaves or scorching of leaf edges may occur. Infected plants are dwarfed and frequently fail to heart, the leaves forming a loose rosette (Fig. 4).

Webb's Wonderful: Vein clearing is the most pronounced symptom. It is often not replaced by mosaic until flower stalks are formed. Symptoms are otherwise essentially the same as those described above.

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* This paper is abstracted from a thesis presented as part of requirements for M.Sc. Degree.

† Also on the staff of the Plant Diseases Division, Department of Scientific and Industrial Research, Auckland.

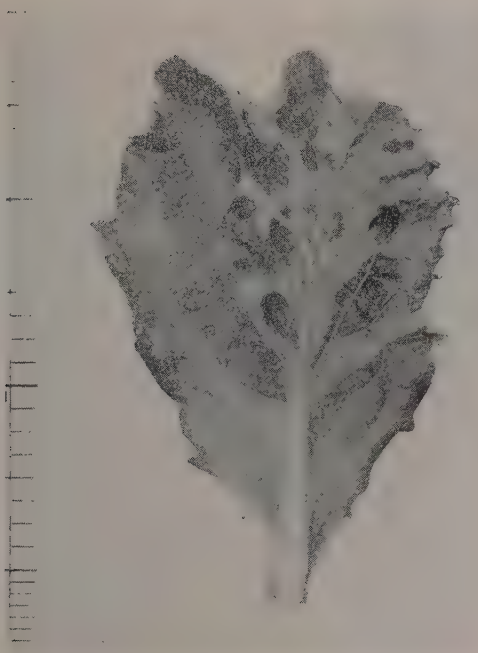

Fig. 1.—Leaf of Imperial 847 lettuce infected by seed transmission showing light green areas.

(*Natural size. Photo by author*

FIG. 2.—Comparison of leaves from healthy and infected Great Lakes lettuce. Healthy leaf on left.

(X $\frac{1}{5}$. *Photo S. A. Rumsey*

FIG. 3.—Comparison of leaves from flower stalks of healthy and infected Imperial 847 lettuce. Healthy leaf in centre.
(X ¾. *Photo by author*

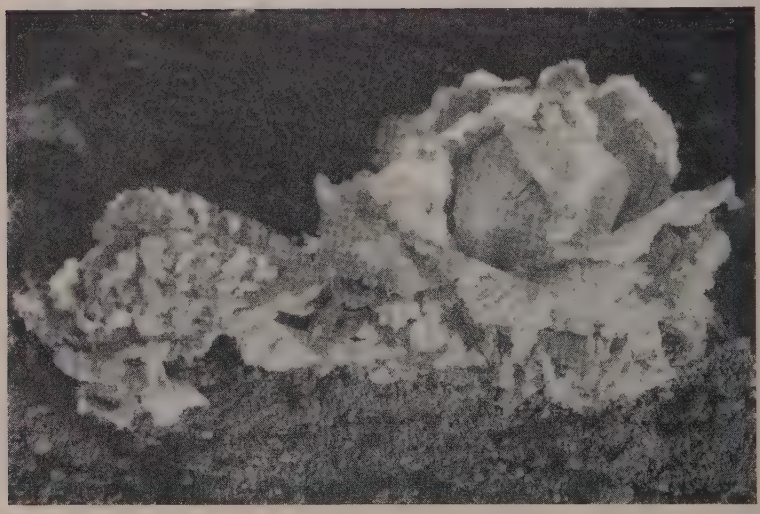

FIG. 4.—Comparison of healthy and infected Imperial 615 lettuce in the field. (*Photo by S. A. Rumsey*

Mignonette: Infected plants are characterized by uneven development of their normal red-brown colour. This causes an interveinal mottle of red-brown and green, the veins remaining green or becoming cleared. Pronounced serration of leaf margins and failure to heart are common symptoms.

All the Year Round: Vein clearing and buckling of interveinal areas are the first symptoms to appear. Leaf edges roll under unevenly, distorting the leaf. In a few days necrotic streaks appear between the veins and still later a blotchy mosaic develops. Leaves on flower stalks are distorted and develop mosaic and necrotic streaks. Dwarfing and rosetting frequently occur.

Cos lettuce (*Lactuca sativa L. var romana Hort.*)

Vein clearing is the first symptom to appear and is usually followed by development of large chlorotic areas bordering the veins, the interveinal areas remaining green. Infected plants are small with leaf-tips turning outwards. Necrosis of veins and leaf edges may occur.

INCIDENCE

Chamberlain (1948) recorded the incidence of the disease in crops at Mangere, Avondale, Hutt Valley and Christchurch. The present writer observed infection in all lettuce crops inspected. These were summer and winter crops at Mangere, winter crops at Avondale, summer crops at Palmerston North, Levin, Hutt Valley and Christchurch, and kitchen gardens at Cambridge, Greytown, Wellington and Motueka.

In 26 commercial crops examined in the above districts incidence of the disease varied between a trace and 100 per cent with an average of 25 per cent. From the data obtained the variation does not appear to be caused by time of the year, age of crop, or variety.

EFFECT ON YIELD

To investigate the reduction in yield which occurred when plants became infected at different stages of growth a winter crop of the variety Imperial 615 was divided into a 4 x 4 latin square, each plot containing 40 plants and separated by buffer rows. The four treatments were as follows:—

A. Plants inoculated at seedling stage (81 days before cutting).
B. Plants inoculated 18 days after planting (57 days before cutting).
C. Plants inoculated 40 days after planting (35 days before cutting).
D. Plants not inoculated.

When the crop was harvested, those plants of check plots which had become infected, and inoculated plants which had failed to develop symptoms were discarded. Twenty-five plants from each plot were then selected at random, weighed and classified as firm hearted, loose hearted or rosetted. Plants with firm hearts were suitable for marketing while many with loose hearts would have become marketable. Rosetted plants were of no commercial value.

The average weights of the treatments were: A, 153 g; B, 215 g; C, 269 g; D, 316 g. As a difference of 23 g is required for significance (1 per cent level) the differences between treatments were highly significant. Infection at seedling stage caused a reduction in crop weight of 51·6 per cent while a proportional reduction was caused by later infection. The numbers of different types of heart formed in each treatment are given in Table I and show that reduction in marketability was proportional to the length of time that plants had been infected.

These results indicate that a heavy infection at an early stage of growth greatly reduces the economic value of the crop.

TABLE I. EFFECT OF LETTUCE-MOSAIC ON HEARTING OF LETTUCE.

Method of Inoculation	Type of Heart		
	Firm (%)	Loose (%)	Rosette (%)
As seedlings	3	69	28
18 days after planting	19	64	17
40 days after planting	33	64	3
Check Sample	73	17	0

METHODS OF TRANSMISSION

Seed Transmission

Lettuce: To extend the work of Chamberlain (1948), to secure information on transmission by seed from infected plants and to ascertain whether infection was present in lines of commercial seed, plants were grown under insect free conditions. Between 200 and 500 seeds of each line were sown well spaced in flat boxes and the plants regularly inspected for infection, but not handled until a final count was made after five or six weeks.

With seed from infected plants of the varieties Imperial 847 and All the Year Round, 6·5 per cent and 15·4 per cent respectively of the plants were infected, while plants grown from commercial seed of the latter variety and of Imperial 615 showed 1·9 per cent and 3·1 per cent infection respectively.

Groundsel: Ainsworth and Ogilvie (1939) showed that lettuce-mosaic virus was carried by seed of infected groundsel plants, but this was not confirmed when 295 plants raised from seed of experimentally infected plants all failed to develop symptoms.

TABLE II. PERSISTENCE OF LETTUCE-MOSAIC VIRUS IN NORMAL AND PREFASTED APHIDS.

(Vector: Mysus persicae. Infection feeding time 2 to 5 min; six plants inoculated in each test.)

Time spent on healthy plants by infective aphids before transfer to test plants. (Min)	Number of Plants infected	
	No. prefasting	No. prefasted 2½ hr
Nil	2	5
15	0	1
30	0	0
45	0	0
60	0	0

TABLE III. APHID TRANSMISSION OF LETTUCE-MOSAIC VIRUS

(Infection Feeding Time: 2 to 5 min)

Date Experiments Commenced	Aphid Species*	Prefasting Time (hr)	Time on Test Plants (hr)	Number of Aphids per Plant	Number of Plants Inoculated	Number of Plants Infected.
23.4.48	Myzus persicae Sulz.	3	1	3	4	3
26.5.48	" "	2½	¼	3	6	5
19.8.48	" "	3	6	3	12	7
31.5.48	Myzus ornatus Laing.	6	-	1	6	0
10.8.48	" "	24	-	6	6	0
8.9.48	Aulacorthum circumflexum Buck.	2	24	6	12	0
23.4.48	Macrosiphum euphorbiae Thomas.	3	1	3	4	2
19.8.48	" "	3	6	3	12	10
12.5.48	Macrosiphum rosae L.	4	-	4	2	0
16.8.48	" "	5	-	6	6	0
12.5.48	Macrosiphoniella sanborni Gill.	29	3	4	2	0
24.8.48	" "	24	16	6	12	0
13.8.48	Aphis gossypii Glov.	2	-	6	6	4
24.8.48	" "	2	18	6	12	7
11.5.48	Lipaphis erysimi Kltb.	2½	-	6	6	0
20.8.48	" "	2½	2	6	12	0
3.9.48	Brevicorne brassicae L.	18	6	6	12	0

* Identification of aphids was made by Dr W. Cottier, Senior Entomologist, Plant Diseases Division.

Aphid Transmission

Aphid transmission of lettuce-mosaic virus has been demonstrated by several authors, the following aphids having been recorded as vectors: *Myzus persicae* Sulz (Jagger, 1921), *Macrosiphum gei* Koch. and *Myzus lactucae* Schr. (Ainsworth and Ogilvie, 1939), *Macrosiphum solanifolii* Ashm*, and *Macrosiphum sonchi* L. (Kramer *et al.*, 1945).

Results obtained by Ainsworth and Ogilvie (1939) show that lettuce mosaic belongs to the non-persistent group of viruses as defined by Watson and Roberts (1939). Experiments in Auckland showed that aphids became infective after feeding on diseased leaves for between two and five minutes, but lost this infectivity in less than 30 minutes when fed on healthy plants. Vector efficiency was increased by fasting aphids before infection feeding (see Table II).

Table III gives results of transmission experiments with several aphid species of which *Myzus persicae*, *Macrosiphum euphorbiae* Thomas (*solanifolii* Ashm) and *Aphis gossypii* Glov. were found to be capable of transmitting lettuce-mosaic virus.

Artificial Inoculation

High transmission rates were recorded by Ainsworth and Ogilvie (1939) when a few drops of 0·5 per cent sodium sulphite solution were added during extraction of inoculum and powdered carborundum was added before inoculation. In the present experiments sodium sulphite and carborundum powder were used together and a transmission rate of 79 per cent resulted when transferring the disease from lettuce to lettuce in trials involving 384 plants.

HOST RANGE

Twenty-two species of plants belonging to 15 genera and four families were tested for susceptibility to the disease. The leaf abrasion method of inoculation was used with all species and aphid transmission also attempted in some cases. Infection occurred with the seven species, endive (*Cichorium endivia* L.), aster (*Callistephus chinensis* Nees), marigold (*Tagetes erecta* L.), cineraria (*Senecio cruentus* D.C.), groundsel (*S. vulgaris* L.), pea (*Pisum sativum* L.) and sweet pea (*Lathyrus odoratus* L.), the first four being new host records. Results of these transmissions are given in Table IV.

In addition to transmitting the disease experimentally to groundsel, this host was found naturally infected in the field. No symptoms were observed in the field, but infection was diagnosed by inoculation to lettuce.

SYMPTOMS ON EXPERIMENTALLY INFECTED HOSTS

Groundsel†

Although no symptoms occurred on an infected plant collected in the field, experimentally infected groundsel plants in the glasshouse showed a transient vein clearing on young leaves seven or eight days after inoculation. After a further seven days small, pale green areas appeared on young leaves and continued to do so throughout the life of the plant.

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* The name of this aphid has since been changed to *Macrosiphum euphorbiae* Thomas.

† Difference in symptom expression between naturally and artificially injected groundsel may be due either to environmental conditions or to difference in strain of virus.

TABLE IV. HOST RANGE OF LETTUCE-MOSAIC VIRUS

Date of Inoculation	Species Inoculated	Method of Inoculation	Number of Plants Inoculated	Number of Plants Infected*
	COMPOSITAE			
14.6.48	Senecio vulgaris L.	Myzus persicae	6	4
16.6.48	"	Leaf abrasion	12	12
23.6.48	Senecio cruentus DC	" "	6	2
"	" "	M. persicae	6	1
9.8.48	Senecio jacobaea L.	Leaf abrasion	4	0
9.7.48	Senecio mikanioides Otto	" "	6	0
21.7.48	Krigeron canadensis L.	" "	6	0
2.8.48	" "	M. persicae	6	0
"	Taraxacum officinale Weber	"	4	0
"	" "	Leaf abrasion	4	0
"	Sonchus asper (L.) Hill	" "	6	0
"	" "	M. persicae	6	0
9.6.48	Sonchus oleraceus L.	"	6	0
9.4.48	" "	Leaf abrasion	6	0
2.8.48	Cichorium endivia L.	" "	6	4
14.6.48	Callistephus chinensis Nees.	" "	4	3
16.6.48	" "	M. persicae	5	1
14.6.48	Chrysanthemum tricolor Andr.	"	5	0
"	" "	Leaf abrasion	4	0
2.8.48	Chrysanthemum morifolium Ram.	" "	4	0
"	" "	M. persicae	4	0
8.6.48	Tagetes erecta L.	"	6	5
"	" "	Leaf abrasion	8	6
9.8.48	Calendula officinalis L.	" "	4	0
	LEGUMINOSAE			
26.4.48	Pisum sativum L.(var.Greenfeast)	" "	10	8
5.7.48	" " (var. Wm. Hurst)	" "	7	3
9.7.48	Lupinus angustifolius L.	" "	6	0
26.4.48	Phaseolus vulgaris L.	" "	6	0
18.3.48	Lathyrus odoratus L.	" "	12	11
9.7.48	Lathyrus tingitanus L.	" "	6	0
23.6.48	Vicia faba L.	" "	9	0
"	" "	M. persicae	9	0
	SOLANACEAE			
5.12.47	Nicotiana tabacuum L.	Leaf abrasion	10	0
	CUCURBITACEAE			
18.2.48	Cucumis sativis L.	" "	6	0

*The number of plants infected was determined by back-inoculation to lettuce. Check plants, equal in number to the plants inoculated all remained healthy.

Endive

Symptom expression was variable, some infected plants remaining symptomless and others developing small chlorotic spots or rings between the veins approximately one month after inoculation.

Marigold

Small circular chlorotic spots appeared on pinnae of young leaves seven to ten days after inoculation. These spots later developed into whitish patches of uneven size and shape.

Aster

Slight clearing of veins and mild chlorosis of the immediately surrounding tissue caused a faint mosaic pattern on young leaves. This pattern disappeared as leaves aged, being replaced by a faint mottle of light and dark green.

Garden pea, Sweet pea and Cineraria

These three species acted as symptomless carriers of lettuce-mosaic virus, no symptoms appearing on infected plants at any stage of growth in these experiments.

No plant of any of the seven experimentally infected species showed any loss of vigour or change in flowering habit when compared with healthy check plants.

PHYSICAL PROPERTIES

The only available record of physical properties of lettuce-mosaic virus is that given by Ainsworth and Ogilvie (1939), details of which are set out in Table IX. In the present experiments infective sap was extracted from All the Year Round lettuce plants which had been infected for approximately one month. Healthy seedlings of the same variety were used as test plants.

Longevity in vitro

The virus was still weakly infective after storage at a temperature of 23°c for 24 hours, but no infections were obtained with sap stored for 32 hours (Table V).

Dilution End Point

When dilution was made with tap water the virus was still infective at a dilution of 1 in 70 (Table VI), and when 0·5 per cent sodium sulphite solution was used as diluting agent the end point was beyond 1 in 150 (Table VII).

Thermal Death Point

Results given in Table VIII show that the thermal death point of the virus lay between 54°c and 55°c.

TABLE V. LONGEVITY OF LETTUCE-MOSAIC VIRUS IN VITRO.

Age of Inoculum (hr)	Number of Plants Inoculated	Number of Plants Infected
0	24	23
8	12	3
16	12	4
24	12	1
32	12	0
40	12	0
48	12	0
56	12	0
64	12	0
72	12	0

TABLE VI. DILUTION END POINT OF LETTUCE-MOSAIC VIRUS WITH TAP WATER.

Dilution	Number of Plants Inoculated*	Number of Plants Infected
1 in 1	17	13
1 in 10	18	15
1 in 20	18	16
1 in 25	18	12
1 in 30	17	9
1 in 35	17	7
1 in 40	18	6
1 in 45	17	5
1 in 50	18	2
1 in 55	17	3
1 in 60	16	3
1 in 65	17	2
1 in 70	17	2

* Plants inoculated 11.6.48.

TABLE VII. DILUTION END POINT OF LETTUCE-MOSAIC VIRUS WITH 0.5% SODIUM SULPHITE.

Dilution	Number of Plants Inoculated*	Number of Plants Infected	Number of Plants Inoculated**	Number of Plants Infected
1 in 1			12	12
1 in 2	17	15		
1 in 20	17	11		
1 in 30	16	7	12	5
1 in 40	16	6		
1 in 50	17	3	12	4
1 in 60	17	4		
1 in 70	17	5	12	3
1 in 80	17	3		
1 in 90	18	2	12	0
1 in 100	15	2	12	2
1 in 110	17	1	12	1
1 in 120	18	1	12	3
1 in 130			12	0
1 in 140			12	1
1 in 150			12	1
1 in 160			12	0

* Plants inoculated 11.6.48.

** Plants inoculated 9.9.48.

TABLE VIII. THERMAL DEATH POINT OF LETTUCE MOSAIC VIRUS.

Date of Experiment	Temperature (°C)	Number of Plants Inoculated	Number of Plants Infected
20.4.48	23	12	10
	50	12	9
	55	12	0
	60	12	0
	65	12	0
18.8.48	17	12	12
	48	12	11
	50	12	9
	52	12	1
	54	12	1
	56	12	0

Filterability

The virus would not pass the L1 Pasteur-Chamberland filter candle.

IDENTITY

The properties of the virus occurring in New Zealand, listed below, agree closely with those described by Ainsworth and Ogilvie (1939) for *Lactuca* virus I of Smith (1937) and show that the viruses are identical.

1. Symptoms on lettuce and experimentally infected groundsel are similar.
2. Groundsel, pea and sweet pea are hosts.
3. The virus is sap transmitted and seed carried.
4. The virus is non-persistent in its aphid vectors, one of which is *Myzus persicae.*
5. Physical properties are either identical or of the same order (see Table IX).

TABLE IX. COMPARISON OF PHYSICAL PROPERTIES OF LACTUCA VIRUS I AND LETTUCE-MOSAIC OCCURRING IN NEW ZEALAND.

Property	Lactuca virus I	Lettuce-mosaic N.Z.
Longevity in vitro	Between 48 and 72	Between 24 and 32
Dilution end point with water	1 in 50 to 1 in 75	More than 1 in 70
Dilution end point with 0.5% Sodium sulphite	More than 1 in 100	More than 1 in 150
Thermal death point	54°C	54°C to 55°C
Filterability	Will not pass L1	Will not pass L1

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DISSEMINATION OF WHITE CLOVER (*Trifolium repens*) BY SHEEP

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Summary

Sheep were fed on pasture containing ripe seeds of White Clover (*Trifolium repens*), and with seed samples in gelatine capsules. The faeces were collected in bags attached to the animals, and the seed extracted.

Germination tests on the seed recovered from dung showed that it was mainly the impermeable seeds which passed undamaged through the digestive tract.

When seed was fed in capsules 30 per cent of a sample of impermeable seed was recovered but only 3 per cent of a sample of scarified commercial seed.

Seed appeared in the faeces within 24 hours after feeding. The maximum daily quantity of seed was passed on the second day, while it continued to appear for a further four days. Examination of a slaughtered sheep showed that clover seed was retained in the involutions of the lining of the third stomach after the 6th day following feeding with seed.

Sheep grazing on a pasture containing approximately 98 lb of ripe white clover seed per acre passed from 1 to 7 g of seed per day.

White clover seed in dung spread on steam-sterilised soil showed a germination of 16 per cent in 155 days. After the first three weeks the rate of germination of the seed in dung was similar to that of the " hard " seeds extracted from dung and incubated at 15°C. on moist filter paper. During the first three weeks the germination in dung was lower than that in the laboratory.

The ecological and agronomic significance of the observations are discussed.

Introduction

One essential requirement in maintaining a high rate of production from pastures is an adequate supply of nitrogen which can be assured most economically by introducing strong growing clovers into the sward. On arable land sufficient clover plants can be readily established by employing a suitable seed mixture when the pasture is renewed, but on unploughable land, where there are no opportunities for the complete renewal of pasture other methods of introducing clovers have to be found.

In New Zealand there are large areas of unploughable land where pastures are deficient in good clovers and the improvement of these pastures is an urgent problem. The problem is being approached in several ways, one of which is the study of natural means of dissemination of clovers. This article deals with the role of sheep in such dissemination.

Several workers have made observations on the effects of animal digestion on seeds and have found that seeds of many leguminous plants may pass uninjured through the digestive tract of sheep and cattle. In no case however has sufficient attention been devoted to the significance of the " hard " seed condition in relation to survival.

Harmon and Kein[1] found that 8·2 per cent of seeds of *Melilotus alba* fed to wethers could be recovered in the faeces. The proportion of hard seeds in the sample was not recorded, but was probably high as treatment of the recovered seed with sulphuric acid raised the germinating capacity, measured by a 14-day test, from 17·1 to 65·9 per cent. These workers also observed that the viability of Melilotus seed stored in cow or horse manure declined rapidly under conditions where fermentation raised the temperature to 158°F., and that no viable seed remained after three months.

Burton and Andrews[2] fed cattle with weighed quantities of seed of *Lespedeza striata*. They found that less than 12 per cent of the seed could be recovered in the dung. Most of the seed was recovered in the first two days, but some was found in dung passed 10 days after feeding. There is no record of the "hard" seed content of the seed fed, or of the seed recovered.

Krefting and Roe[3] quote work by Troup who found that seeds of *Acacia arabica* germinated more readily after passing through the digestive tract of sheep and goats, the germinating capacity being raised from 7 to 35 per cent in this way.

Dore and Raymond[4] recorded the number of clover seedlings produced from seed in the dung of cows. They observed that at the conclusion of their tests clover seed which appeared to be sound still remained ungerminated, but they did not ascertain the quantity nor the viability of this seed.

The possibility of using animals for disseminating seed of pasture plants has been discussed by Burton and Andrews[2], while von Hessberg[5] draws attention to a practice of farmers in Germany. Having observed that ripe white clover seed passes uninjured through the alimentary canal of animals, they turn young animals, sheep for preference, into a field where white clover plants are in full seed. The sheep are subsequently transferred to a field where it is desired to establish white clover. From these recorded observations however, no detailed information is available as to the effectiveness of sheep in distributing clover seed in this way, or to the significance of the hard seed condition in relation to the survival of clover seed in the alimentary tract of the animal. The present work was undertaken to throw light on these two points.

EXPERIMENTAL PROCEDURE

Animals used

In all trials four-year-old wethers were used as the grazing animals, being selected at random from a flock of 100 wethers of like size which were all accustomed to being harnessed for experimental purposes.

Method of Feeding

To ensure that the experimental sheep ingested known quantities of seed, gelatine capsules holding approximately 1 g of white clover seed were fed to the sheep by means of a standard phenothiazine "gun". The number of capsules fed varied between five and ten. Observations following the dosing process showed that the majority of the seed passed safely into the stomach without suffering injury through mastication, although some seed was probably regurgitated and chewed with the cud.

Method of faeces collection

The experimental sheep were harnessed and canvas bags attached for catching the faeces, in the manner described by Sears and Goodall[6]. In order to prevent spilling or overfilling of bags, faeces collections were made twice daily. Dung quantities increased during wet weather and became a soft mass ; conversely, dry feed produced pelleted dung and in smaller quantity. Over a total of 86 dung collections from 6 sheep the average daily output per sheep was 4·1 lb of fresh dung.

Methods of extraction

The total quantity of dung from each sheep was collected daily, weighed and mixed. A 1,000-g sample for seed analysis was taken by subdividing the total quantity of dung into small heaps, and then taking up these at random until the required weight was obtained.

The sample of dung was placed in a cloth bag and thoroughly macerated under water. After the pellets were broken down the bag was emptied into a bucket and placed under a tap, where by flotation and decantation the light fibrous material and mucilaginous matter was washed away, leaving the coarser fibres and seed remaining in the bucket. During the flotation process, a number of empty seed coats as well as some clover embryos from partly masticated seed floated to the surface showing that in the process of grazing or cud chewing, damage occurred to the seed being consumed. It is possible that in the process of maceration some swollen seeds were damaged. The small quantity of fibre and seed remaining was readily air-dried and the seed separated out by sieving. The seed recovered was found to vary greatly in colour, and was separated into two classes :

Class 1. Seeds of normal colour, yellow to reddish brown ;

Class 2. Seeds of abnormal colour, olive-green to black.

It was found that Class 1 consisted of hard seeds, i.e. seeds in which imbibition is delayed through impermeability of the testa. Class 2 were permeable seeds which had absorbed stomach juices. The seeds in the two classes were air dried and weighed separately.

Germination tests

Germination tests were carried out on two samples of 100 seeds counted at random. The seeds were placed on moist filter paper in Petri dishes and incubated at 15°C. The normal duration of the tests was 16 days, but more prolonged tests were carried out on samples of hard seeds.

Grazing experiment

To determine whether sheep freely consumed white clover seed heads when grazing a clover pasture, and to follow the progress of the seed through to the faeces, a wether was confined in each of two separate 10 ft × 10 ft square cages on pasture which contained white clover seed heads (Fig. 1). The trial commenced in mid January when about half the seed heads ranged from the flowering stage up to the stage where the seed was mature but unripe (Fig. 2). As the trial progressed a higher proportion of ripe heads was available.

The two sheep were harnessed with faeces-collection bags, and the total daily output of dung was collected from each animal. The cages were shifted each morning at the time of collection to a fresh area of

FIG. 1.—Wether in 10 ft x 10 ft cage grazing pasture sward containing white clover seed heads.

FIG. 2.—Pasture sward showing seed heads ranging from flowering stage up to stage where seed mature but unripe.

clover pasture. Over the 24-hour period the sheep grazed down the 100 sq ft of pasture fairly uniformly, leaving only coarse stems of grass and some tramped-down clover heads and leaves (Fig. 3). Most of the clover heads, however, were consumed ; in fact, on entering a new area the sheep displayed a preference for clover heads. The quantity and physical condition of the faeces varied according to the amount and nature of the previous day's feed.

FIG. 3.—Pasture sward after being grazed for 24 hour period.

Seed was extracted from a 1,000-g sample, classified according to colour, then weighed and tested for germination. In the germination tests the seeds were classified as follows :

(a) Seeds germinating in 16 days ;
(b) Abnormal growths ;
(c) Hard seeds ;
(d) Dead seeds.

To ascertain whether they were viable the hard seeds from seven samples were scarified and returned to the incubator. These seeds had been extracted from dung and had failed to germinate after 28 days on moist filter paper, at 15°C. After scarification 92 per cent of the seeds germinated in seven days, 7 per cent produced abnormal growths and 1 per cent remained hard. The abnormal growths appeared to be due to injury suffered during scarification. In view of these results it was considered reasonable to assume that all hard seeds recovered from dung were viable.

TABLE I. SEED RECOVERED FROM DUNG OF TWO SHEEP GRAZED ON PASTURE INCLUDING WHITE CLOVER SEED HEADS

Days from commencement of grazing	Amount of seed recovered in dung Sheep 1		Amount of seed recovered in dung Sheep 2	
	Normal colour (mg)	Discoloured (mg)	Normal colour (mg)	Discoloured (mg)
1	400	405	58	1,446
2	1,477	100	748	2,546
3	1,664	242	1,106	524
4	1,790	184	1,405	273
5	1,410	270	1,270	210
6	1,932	259	3,106	644
7	799	116	4,106	708
8	1,605	460	3,392	1,287
9	4,507	969	989	1,359
* 10	3,675	762	2,389	760
11	2,793	271	1,554	290
12	424	71	1,660	220
13	91	34	372	184
14	23	1	358	44
15	11	0	22	0
16	0	0	0	0
17	0	0	0	0

* Grazing of clover discontinued and sheep transferred to clover-free sward.

The results are shown in Table I where it is seen that seeds of normal colour were almost all viable, but that only 5 per cent germinated within 16 days, the remainder being hard. Of the discoloured seeds only 11 per cent were viable and none were hard. The non-viable seeds included 9 per cent which produced useless abnormal growths. Generally speaking it was the hard seeds only that passed through the animal without apparent injury, whereas the permeable seeds were either non-viable or produced abnormal growths.

The mean daily output of seed per sheep during the period when grazing on the clover sward was 1891 mg of normal coloured seed and 676 mg of discoloured seed.

To ascertain the length of time required to evacuate seed from the stomach and intestines of sheep, the two animals were removed from the clover pasture and held on a pure sward of ryegrass aftermath containing no clover. The sheep continued to pass seeds in their faeces, in declining numbers for a period of seven days following their removal from the clover sward. The total quantity of seed collected during this seven-day period was of the same order as the amount of seed passed daily while the sheep were grazing the clover sward.

Capsule feeding experiments

The previous experiment had indicated that only the hard seed passed through the digestive tract of sheep without considerable loss

of viability. To investigate this point further experiments were carried out in which two different lots of clover seed were fed to sheep :

(1) *Unscarified Seed :* Hand-harvested white clover, which was not subjected to any scarification in cleaning or harvesting. A sample of this seed germinated 2 per cent, the remaining 98 per cent being hard seed.

(2) *Scarified Seed :* Commercial white clover which in the process of machine-harvesting and dressing, had become scarified to the extent that the sample germinated 93 per cent in 16 days, with 2 per cent hard seed, 2 per cent abnormal growths, and 3 per cent dead seeds.

Two sheep were grazed for seven days on a pure grass sward. At the end of this period the faeces were examined and found to be free from clover seed. Faeces-collecting bags were attached to the sheep and five gelatine capsules of white clover seed were fed to each sheep. Sheep No. 1 received the unscarified seed and Sheep No. 2 the scarified seed. Immediately following dosing, the sheep were returned to a clover-free pasture. Faeces were collected daily for a period of five days, and the white clover seed recovered and classified according to colour. At the end of the collection period germination tests were carried out on the seeds of normal colour recovered from each sheep. The results are shown in Tables II and III.

TABLE II. CAPSULE FEEDING TRIAL: COMPARATIVE RECOVERY OF HAND-HARVESTED AND COMMERCIAL WHITE CLOVER SEED FROM FAECES OF SHEEP

Sheep No.	Amount of seed ingested (mg)	Days after dosing	Normal colour		Discoloured		Normal and discoloured	
			(mg)	(%) *	(mg)	(%)*	(mg)	(%) *
1. Fed with hand-harvested seed.	6690	1	777	11.6	132	2.0	909	13.6
		2	1080	16.8	0	-	1080	16.2
		3	107	1.6	10	0.1	117	1.7
		4	13	.2	0	-	13	.2
		5	0	-	0	-	0	-
Total seed recovered			1977	29.6	142	2.1	2119	31.7
2. Fed with commercial seed.	7601	1	108	1.4	54	.7	162	2.1
		2	76	1.0	0	-	76	1.0
		3	0	-	0	-	0	-
		4	0	-	0	-	0	-
		5	0	-	0	-	0	-
Total seed recovered			184	2.4	54	.7	238	3.1

* based on total seed ingested.

TABLE III. GERMINATION OF WHITE CLOVER SEED BEFORE AND AFTER PASSING THROUGH SHEEP

Seed Sample	Before Feeding			Collected from Dung		
	Germinated (%)	Hard Seeds (%)	Abnormal Growth (%)	Germinated (%)	Hard Seeds (%)	Abnormal Growth (%)
Unscarified Seed	2	98	0	4	96	0
Scarified Seed	93	2	3	19	80	1

Table II shows that the recovery rate of hand-harvested seed is much higher than that of commercial seed, viz. 32 per cent as compared with 3 per cent. Moreover, with the hand-harvested seed, 93 per cent was of normal colour, while with commercial seed the corresponding figure was only 77 per cent. These results would indicate that while a large proportion of seeds ingested by a sheep may be destroyed, the survival rate of hard seeds in the digestive tract of the sheep is much greater than that of permeable coated seeds, even when these seeds are mature.

In the previous experiment only two sheep were used and the treatments were not replicated. The experiment was therefore repeated using the same technique throughout but duplicating each treatment. The results are presented in Table IV. The proportions of the seed recovered in the dung of the sheep to which it had been fed were of the same order as in the first experiment. Of the scarified sample 2·1 per cent was recovered and of the unscarified sample 27 per cent was recovered. It is especially noteworthy that 456 mg of hard seeds were recovered from the two sheep fed with 21,859 mg of the scarified sample. This commercial seed contained approximately 2 per cent of hard seeds and it appears that all this seed passed uninjured through the sheep. Of the hand-harvested seed of which 98 per cent was hard seed, 27 per cent was recovered.

TABLE IV. CAPSULE FEEDING TRIAL: SOUND SEED RECOVERED IN FAECES OF SHEEP FED CLOVER SEED AND THEREAFTER GRAZED ON CLOVER FREE PASTURE

Days from dosing	Mg of scarified seed recovered in faeces		Mg of unscarified seed recovered in faeces	
	Sheep 1 (fed 10906 mg)	Sheep 2 (fed 10953 mg)	Sheep 3 (fed 10361 mg)	Sheep 4 (fed 10225 mg)
1	26	35	299	898
2	247	49	1827	926
3	27	5	73	849
4	14	49	11	275
5	4	0	21	378
6	0	0	0	52
Seed recovered	318	138	2231	3378
Recovered seed as % of seed fed	2.9	1.2	21.5	33.0

To determine whether any seed remained in the sheep's stomach and intestines after six days, when three of the four sheep showed no trace of seed in their dung, it was decided to kill Sheep No. 4 which had been fed hand-harvested white clover seed. All stomachs and intestines were opened up, the contents washed and seed recovered. The seed was distributed in the digestive tract as follows :—

Location of Seed	*Quantity of Seed* (mg)
Rumen	0
Reticulum	12
Omasum	1307
Abomasum	99
Small intestine	76
Large intestine	65
Total	1559

Most of the seed found in the animals digestive tract was lodged between the "leaves" and folds of the omasum. In view of this fact, it is possible that small quantities of seed would pass out for a considerable time after ingestion. All the seed recovered from the digestive tract of the slaughtered animal was in the hard condition.

Ratio of the quantity of seed passed by sheep to the quantity available to them under grazing conditions.

As the capsule feeding experiment summarised in Table II imposed conditions different from those which obtain under natural grazing a further experiment was carried out to ascertain the quantitative relations between seed content of natural herbage and the viable seed content of the faeces.

Two sheep were used in this experiment, and as in the previous experiments they were pre-grazed on a pure ryegrass sward for seven days to ensure that their faeces contained no clover seed. The sheep were then placed in two 100 sq ft cages on clovery pastures. Prior to shifting the sheep into the cages, estimations were made of the quantity of seed available in each cage. A square foot quadrat was placed at random on the pasture to be grazed and all white clover seed heads whether mature or immature were plucked from the sample area. Four such samples were taken from each 100 sq ft enclosure. The cages were shifted daily, and sampling of the herbage for clover seed content was carried out in the above manner each day before grazing.

An estimation was made of the total quantity of clover seed in the herbage available to the sheep and also of the proportion of hard seed. The clover seed heads in each sample were separated into ripe and unripe heads. Seed from the ripe heads was rubbed out and placed in water for 24 hours. The hard seeds which had not absorbed water were then easily separated by sieving. These hard seeds were weighed separately. The permeable seeds from the ripe heads together with all the seeds from unripe heads were brought to the air-dry condition and weighed.

Simultaneously with the estimation of total quantities of seed available, faeces samples were collected and the clover seed washed from the dung. The two experimental sheep were given fresh clover areas to graze on each of four consecutive days after which they were once more returned to a pure grass sward. Faeces sampling continued for a further seven days, by which time the dung showed that no further seed was passing through.

The results of this experiment are shown in Table V.

The table indicates that the quantity of seed recovered in the dung represented only a small proportion of the seed available in the feed. Of the 4·3 per cent of the available seed recovered from Sheep 1, 3·3 per cent was hard, and 1 per cent swollen discoloured. Of the hard seed available, 7 per cent was recovered as hard seed. From Sheep 2 only 0·76 per cent of the seed available in the feed was recovered, 0·65 per cent being hard seed, and 0·11 per cent swollen discoloured seed. Of the hard seed available to the animal 1·86 per cent was recovered in this form in the dung.

There was a large difference in the proportions of seed recovered from the two sheep. It was observed that due to restlessness of the Sheep 2 there was a greater wastage of feed through tramping down of the herbage. Although wastage was not measured, it did not appear sufficient to account for the difference between the sheep.

TABLE V. CLOVER SEED CONTENT OF FEED INGESTED AND DUNG EXCRETED

Sheep No.	Days from commencement of grazing	Hard seed (mg)	Hard seed plus permeable seed (mg)	Hard seed (mg)	Hard seed plus permeable seed (mg)
1	1	55,200	127,000	0	0
	2	87,900	163,000	823	1,100
	3	123,000	296,000	5,040	6,560
	4	134,000	266,000	7,520	9,510
	* 5			8,000	10,500
	6			6,040	7,850
	7			375	387
	8			150	155
	9			91	91
	10			28	28
	11			0	0
Total seed recovered		400,100	852,000	28,049 (7% of total hard seed fed)	36,281 (4.3% of total seed fed)
2	1	67,100	176,000	0	0
	2	70,300	136,000	7	7
	3	34,400	281,000	982	1,300
	4	97,900	183,000	921	1,000
	* 5			1,660	1,970
	6			851	1,010
	7			553	595
	8			35	35
	9			0	0
	10			0	0
	11			0	0
Total seed fed and recovered		269,700	776,000	5,009 (1.86% of total hard seed fed)	5,917 (0.76% of total seed fed)

* Removed to clover free sward.

The grazing habits of sheep

To observe whether sheep under normal grazing conditions would select clover seed heads, when grazing a clover pasture, four sheep were harnessed and "bagged", and grazed on an area containing a relatively poor white clover seed-head content. Dung was collected after two days grazing on the area, and the samples of faeces were washed to separate the seed. Even under poor seed-crop conditions each sheep passed an average of 3 g of white clover seed per day.

During the period of grazing, observations were made on the grazing habits of the four sheep. Under natural grazing conditions the sheep consumed seed heads where there was a wide choice of grass and clover pasture. At times they appeared to show a preference for the seed heads, and selected them from among other apparently lush feed.

Germination of seed from dung

To determine the germination of seed which has passed through the animal, tests were carried out both in the field and under laboratory conditions. On 8 February, 1950, twelve 10-in. pots were filled with

sterilised soil and buried in clean open ground to within 1 in. of the top of the pot to prevent entry of surface water and contamination from the surrounding soil. The soil in the pots was brought to ground level to ensure an even moisture supply and to simulate normal soil conditions.

All twelve pots were uniformly watered when placed in position but received no subsequent treatment. On six pots dung pellets were pressed into the soil, while in the other six pots pellets were merely dropped on the surface. A 500-g sample of the mixed dung was tested and found to contain 5,464 hard seeds and 1,514 soft swollen seeds. Fifty grams of dung pellets were used per pot and it was estimated that the clover seeds in each pot numbered 546 hard seeds and 151 immature seeds.

Counts were made periodically of the clover seedlings that emerged, and as plants became established they were carefully removed to allow for counting of future seedlings.

Table VI gives the emergence of seedlings over the period 8 February, to 13 July, 1950.

TABLE VI. GERMINATION OF CLOVER SEED IN SHEEP DUNG UNDER FIELD CONDITIONS
(Trial commenced, 8.2.50)

Treatment	Pot No.	Cumulative numbers of clover seedlings emerging up to indicated date						
		27.2.50	7.3.50	28.3.50	11.4.50	24.4.50	16.6.50	13.7.50
Dung Pellets on Soil Surface	1	14	14	28	46	52	72	81
	2	18	18	19	28	40	60	68
	3	19	20	25	33	49	77	101
	4	27	31	31	39	44	69	113
	5	20	24	30	45	52	73	93
	6	13	14	19	23	31	50	71
	Mean	18.5	19.8	25.3	35.7	44 6	66.8	87.8
Dung Pellets Pressed Into Soil	7	10	10	24	36	40	52	58
	8	16	16	20	42	53	72	79
	9	21	23	24	48	61	90	126
	10	11	11	14	17	26	41	71
	11	21	22	24	34	43	60	102
	12	10	11	20	24	29	45	72
	Mean	14.8	15.5	21	33.5	42	60	34.6

Concurrently, seed extracted from a sample of the same lot of dung was submitted to a laboratory germination test. In ascertaining by laboratory test the speed of germination of seed from dung, care was taken to avoid drying the seed prior to the tests. Seeds which had absorbed moisture were sieved off from the hard seeds and separate germination tests were carried out on the latter.

The results of the laboratory germination tests and field counts are shown in Fig. 4.

Earlier experiments had shown that seeds which were permeable at the time the faeces were voided had a low germinating capacity and included a high percentage of injured seed producing abnormal growths. In recording the germination of seed in dung it was therefore assumed that only those seeds which passed through the animal in the hard condition were capable of remaining viable through the period of fermentation of the dung.

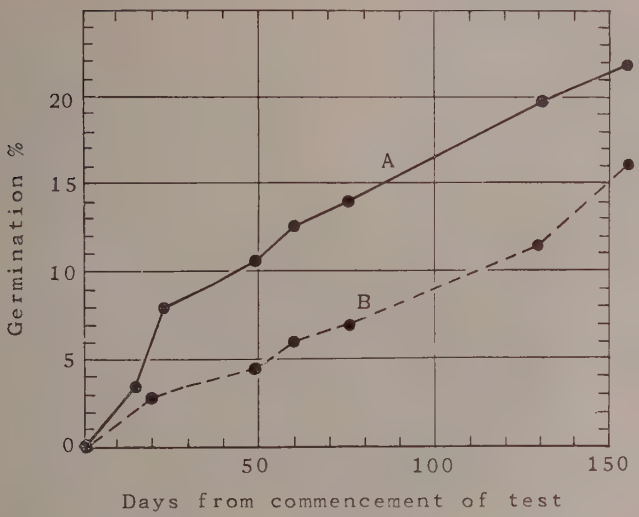

FIG. 4.—Germination of white clover seed.
A. Laboratory test of hard seed extracted from fresh dung.
B. Germination from dung under field conditions (based on estimated hard seed).

In the laboratory the rate of germination of hard seeds extracted from fresh dung was comparatively rapid in the first three weeks, and thereafter remained nearly constant at a lower level. The rate of germination of the seeds from dung in the pots of soil was approximately the same as that in the laboratory after the first three weeks. It is possible that the difference in the germination curves is due to the non-survival of those seeds which became permeable in the dung during the first three weeks when the dung was rotting.

DISCUSSION

The present work indicates the importance of the hard seed condition in relation to the natural dissemmination of white clover by animals. Sheep graze freely on the seed heads of white clover, consuming ripe and unripe heads apparently without discrimination. Most of the permeable seeds from unripe heads are destroyed in the process of mastication and digestion, and the few that are viable at defaecation do not appear to survive the period of fermentation of the dung. The impermeable seeds from ripe heads have a higher survival rate, although it is clear that a large proportion of these may likewise be destroyed.

Where sheep were fed hard seeds of white clover in capsules, 32 per cent of the seed was recovered in the dung. Sheep which were similarly fed with seed containing only 2 per cent of hard seed, destroyed almost all the permeable seed while practically the whole of the hard seed passed through the animals undamaged.

The feeding of seed in capsules introduces several factors which make it impossible to compare the results directly with those obtained under grazing conditions. Firstly there is no initial mastication and secondly the seed being free from the seed heads, may not be regurgitated and chewed with the cud in the normal manner.

As mature scarified seed was used, these experiments showed that the non-survival of permeable seeds was not the result of any weakness due to immaturity.

The rate of germination of white clover seed in dung in the field is very similar to the rate of germination of hard seed in the laboratory. Only during the first four weeks of the testing period was the rate in the laboratory higher than that in the field. This may have been due to the non-survival of some seedlings in the fermenting dung, or to desiccation of some germinating seeds.

Apparently it is only the hard seeds remaining viable after the fermentation of the dung which are effective in the dissemination of white clover. Germination is delayed by the impermeability of the seed coat, and is spread evenly over a long period. In this climate there appears to be little seasonal fluctuation in the rate of germination. The fact that some of these seeds germinate at all seasons of the year may help to ensure the survival of a proportion of the seedlings in the field.

After feeding, seed appeared in the faeces within 24 hours, was excreted in maximum quantity on the second day, and continued to appear until the sixth day after feeding.

The fact that seed was still present in the alimentary canal of a sheep slaughtered six days after feeding with seed indicates that the passing of seed may continue over a still longer period in diminishing quantities. This accords with the observations of Burton and Andrews[2], and of Harmon and Kein[1].

It has been estimated by Dore and Raymond[4] that the numbers of viable seed of red clover and alsike which might be distributed in the dung of one cow in a grazing season were 1,100 and 900 seeds respectively. This estimate was based on the number of seedlings obtained from dung in germination tests lasting approximately four months. This estimate is certainly too low, as no account was taken of " hard " seeds which were still ungerminated at the time the counts were discontinued.

In the present studies, measurements were made of the quantity of ripe seed present in a pasture and the quantity of viable seeds passed by the animals grazing the pasture. It was estimated that " hard " seed available in the feed amounted to 98 lb per acre and that under a rate of stocking where the feed was grazed down in one day, the amount of viable seed distributed through the faeces of sheep was approximately 4·5 lb comprising about 4,000,000 seeds.

There was a great difference between animals in regard to the quantity of seed in the faeces. Similar observations were made by Burton and Andrews[2].

The present work indicates that the practice referred to by von Hessberg[5] is worthy of trial under New Zealand conditions. Areas of white clover which are in the ripe head stage could be grazed by a large flock of sheep and the stock then turned out on to clover deficient hill country. It is possible that two or more grazings of a clover crop could be made during a flowering season.

This method of disseminating seed of pasture plants has been considered by Burton and Andrews[2]. They discuss the practicability of establishing small areas of Bahia grass in widely separated strips as sources for seed distribution by cattle in cut-over timber land in South East Georgia. The method outlined could be adopted where ploughable country is farmed in conjunction with hill country, and where climate,

topography, and lack of machinery make the harvesting of white clover seed impracticable. White clover crops could be grown and fed to animals which are then transferred to hill pastures. While the proportion of clover seed disseminated in this way is not great the seed which is destroyed cannot be regarded as entirely wasted because of its high food value when digested.

The ability of stock to disseminate seed on hill country could also be exploited by feeding clover hay with a high seed content. This practice would appear to have obvious advantages over that of mixing commercial seed in chaff, bran or other feed. Whereas in clover-hay most of the seed is in the hard condition, in commercial lines it has, by scarification in the process of harvesting and cleaning, been rendered permeable to moisture and hence more readily digestible by the animal.

The natural impermeable condition of clover seed is of significance not only in regard to survival in the passage through the animal but also because its germination is spread over a long period of time. In these experiments where dung containing hard seeds was spread on soil, clover seedlings continued to appear throughout the autumn and winter. Where seed is sown on an established pasture, conditions are liable to be much less favourable for the survival of seedlings than on a seed bed prepared by cultivation. Under such conditions it may be advantageous to have the seeds germinate over a long period rather than all together on the first occasion when temperature and moisture conditions are favourable.

Striking examples of the effectiveness of delayed germination in ensuring survival of clover have been noted on hill country in old stands of subterranean clover. Successive lots of seedlings emerge during summer and autumn, only to be destroyed by subsequent periods of drought. Seedlings emerging later when there is a continuity of moisture supply, persist and ensure a satisfactory stand.

Further work is being carried out to determine the possibility of harvesting clover with a high proportion of hard seed and using this class of seed for oversowing hill pastures.

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A BOTANICAL SURVEY OF A PEAT AREA BETWEEN RAUMATI SOUTH AND PARAPARAUMU

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Summary

An investigation was carried out on 488 acres (198 hectares) of peat lying between Raumati South and Paraparaumu on the coastal peat belt formed as a result of a prograding coast-line on the West Coast of the North Island of New Zealand. The principal plant communities were examined in relation to the biotic factors of fire, draining and stock, and to the ash content and pH of the peat. Six plant communities, representing developmental stages in reclamation of the area were distinguished, viz. bracken-manuka-gorse community, bracken community, manuka community, gorse community, swamp community and a pasture community. A brief outline of the possible dominant forest species in the primitive association is based upon a number of wood samples. The peat and peat-depths are briefly discussed.

INTRODUCTION

A botanical investigation of 488 acres (198 hectares) of peat extending from Poplar Avenue, Raumati South, to one mile north of Paraparaumu township was undertaken at the request of the Wellington Regional Planning Council.

The area examined is only a small portion of the mire* belt extending along the West Coast of the North Island. The peats investigated are bounded to the west by weakly consolidated sand-dunes and to the east by steep greywacke hills representing an old coast line, and occupy a small part of the coastal plain originating at Paekakariki and gradually broadening to the Horowhenua Plain (Oliver, 1948).

The peat has accumulated in valleys and depressions among sand-dunes formed as a result of progradation. These sand-dunes effectively block drainage from the adjacent hills, causing an accumulation of water and thus initiating mire conditions. As the peat accumulated, depressions would be filled and smaller dunes submerged, finally forming the level plain interlaced by weakly consolidated sand-dunes.

Originally the whole district including the peat areas was forested, but in the process of reclamation of the area and its utilization the primitive association and the original peat surface has been destroyed. Charred stumps and roots are the only indicators of the primitive association.

Borings carried out by the Ministry of Works show that the peat overlies varying thicknesses of sand deposits which in turn rest upon shingle. In some localities there has been an accumulation of clay below the peat, or the clay is interbedded with the peat and sand. A series of borings extending from Paekakariki to Paraparaumu showed that the deepest peats are in the vicinity of Poplar Avenue, Raumati South. The figures supplied would indicate that the peat has an average depth of almost 2 m.

* Mire is a general term to indicate any area of swamp or bog. It is derived from the Swedish "myr." (Selling, 1948.)

A further series of borings made with a Swedish peat auger, between Poplar Avenue and Paraparaumu gave an average depth of 2.5 m, while the greatest peat depth of 3.75 m was found just north of Poplar Avenue. The shallowest peat was on the fully reclaimed area E, where a depth of 1.08 m was recorded.

The peat is predominantly of forest origin, and consists of wood remains. Fern fragments were found in the upper layers, rush or sedge fragments in the lower layers.

There are considerable quantities of sand and silt distributed through the peat, which has been carried by streams and run-off from marginal greywacke hills, and also blown by wind from the coastal sand-dunes. The presence of this material has no great effect upon the existing plant communities, but it was undoubtedly a contributing factor to the presence of the primitive forest vegetation.

As with most lowland mires in New Zealand, efforts have been made to utilize the peat as farm land. Where management has been good, the peat has been reclaimed to useful dairy land. Where management has been careless, the peat has been destroyed by fire, and dense induced communities of *Pteridium esculentum* (bracken), *Leptospermum scoparium* (manuka) and *Ulex europaeus* (gorse) have developed. Of that portion of the area which has been reclaimed, 7 acres* (3 hectares) are used for market gardening and 263 acres (106 hectares) are under pasture. The remaining 218 acres (88 hectares) are in some stage of reclamation or have been so badly managed that reclamation would be difficult.

METHODS OF INVESTIGATION

The construction of the vegetation map (Fig. 1) was greatly facilitated by the use of aerial photographs.

In the field, distinct areas were arbitrarily lettered to simplify mapping and description of the plant communities.

Detailed notes on plant communities were made with especial attention given to the relationship between the three dominant species and the biotic factors. Line transects were taken along drains and bore-lines, but because of the disturbed nature of the vegetation, gave results of little significance.

Wood samples were collected for identification in the hope of gaining some idea of the primitive vegetation.

Peat samples were collected and the pH determined with a Beckman electric pH meter, using glass and calomel electrodes. Other samples were sent to the Dominion Laboratory for analysis. In addition, some 400 samples were collected for pollen analysis, and, as these were taken, the botanical composition of the peat was noted. Pollen results are beyond the scope of the present paper.

BIOTIC FACTORS

Although the primitive vegetation and consequently the peat, developed under conditions of a high water-table, the most important factors now affecting the plant communities are the biotic ones of fire, draining, and grazing and trampling by stock.

* These areas are only approximate and were determined by Lands and Survey Department from a map supplied by the author.

Where these factors have been properly applied, the peat has been completely reclaimed as the area under pasture already mentioned. Where the biotic factors have not been controlled, as has happened on parts of the peat area investigated, the peat is rapidly becoming waste land.

Fire

Not only has fire destroyed the peat surface, but it has also destroyed the plant communities growing on the peat; the effects of fire can be seen on all but the completely reclaimed peats. The hummocky nature of

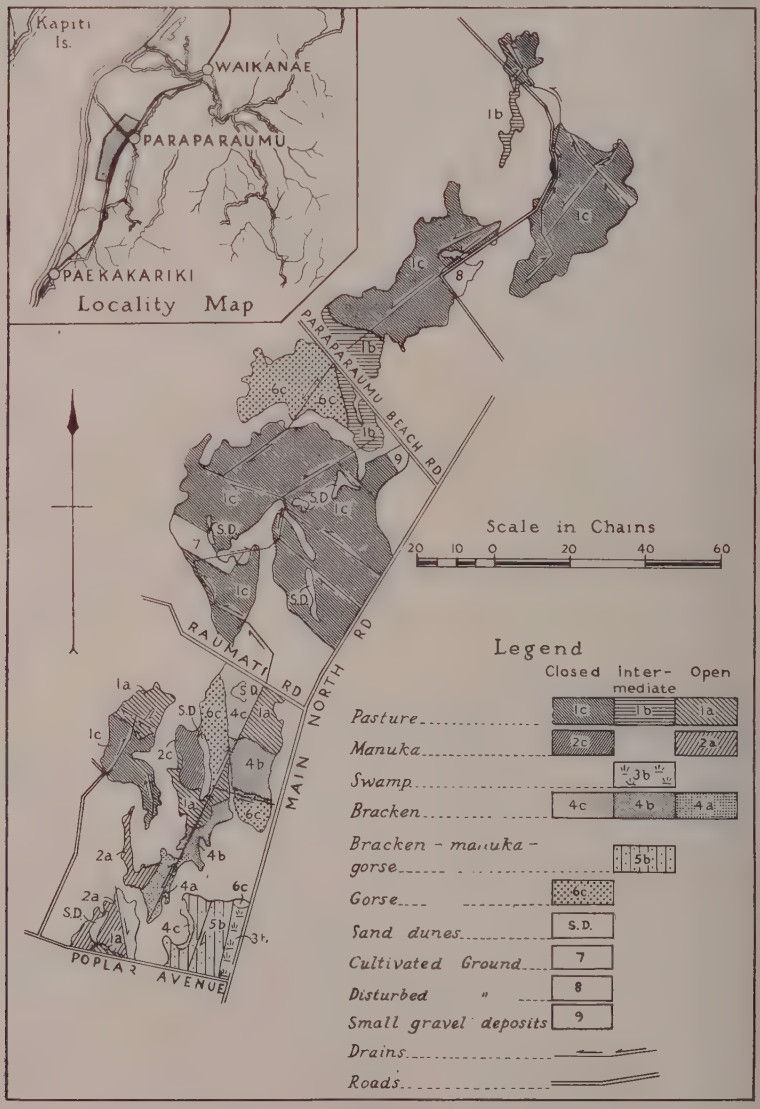

FIG. 1.—Vegetation Map of area between Raumati South and Paraparaumu.

much of the peat surface is the result of unequal burning. In two places the peat had been burnt to the summer water-table level, presenting deeply pitted, stumpy areas which could be reclaimed only with difficulty (Fig. 2). Fire does more harm than good as it cannot be easily controlled.

Development of the plant communities, except the pasture community, is now controlled to a large extent by fire. Continued burning can lead to the establishment of a dense gorse or bracken community as the burnt peat surface forms a fine bed for gorse seeds and bracken spores. Under a large gorse plant recently destroyed by fire, the substratum was covered with a dense growth of gorse seedlings.

Burning tends to concentrate ash at the peat surface and an ash layer can be readily seen in exposed profiles of burnt peat in the peat area.

FIG. 2.—Marginal peat deeply burnt, revealng roots and stumps of a former forest vegetation.

Draining

Although drainage is not rapid, the peat area is now generally well drained by outlets which have been cut through the sand-hills to the sea. In one place at Poplar Avenue, the road embankment has caused a local rise in the water-table level.

Drainage results in the lowering of the water-table level, followed by the gradual shrinking of the peat surface. In the case of the Raumati South-Paraparaumu peats, which are extremely woody, the shrinking peat surface has revealed in parts great numbers of stumps, indicating the remains of at least part of the primitive association. That the peat surface has shrunk is indicated by a sudden drop of about a meter from

the slope of the consolidated sand dunes to the present peat surface which is observable along most dunes bordering the peat. However, the lowering of the peat surface is not only attributable to the effect of draining, but also to burning and the trampling action of stock.

With the lowering of the water-table, bracken begins to establish itself. A well drained area of 23.5 acres (10 hectares) not recently burnt has a well developed community dominated by bracken. Another poorly drained area of 13 acres (5 hectares) in which the water-table has risen, is developing a *Gleichenia circinata* community in which dead bracken is frequent. Here bracken is flourishing only along the drain sides.

On the slowly consolidating surface of the reclaimed and well drained peat, a pasture has been satisfactorily established.

Stock

Stock play an important role in the development of this peat area. They help consolidate the surface by constant trampling, complementing the action of draining. A noticeable feature was that the most consolidated peats were those open to stock. The completely reclaimed peats were well consolidated and were continually stocked by cattle.

The grazing by cattle affects the development of communities on unreclaimed peats. Gorse seedlings especially are heavily grazed, manuka, to a lesser extent. On an area of 24 acres (10 hectares) open to stock for a considerable period of time, gorse is virtually absent, whilst manuka is prevented from becoming the dominant species. Bracken, which is only lightly grazed, is able to develop rapidly. Where stock have no access to unreclaimed peat, manuka and gorse can rapidly become dominant and once a manuka or gorse community is well established, grazing stock cannot easily destroy or even control it.

Peat Analysis

Because the biotic factors have been effective for some considerable time, the results of the analyses cannot be regarded as being indicative of the peat under primitive conditions. The surface layers of peat are especially affected by the biotic factors.

Two series of samples were collected, one north and the other south of Poplar Avenue, and forwarded to the Coal Section, Dominion Laboratory for analysis. Table I and the following comments are based on the report of the Dominion Analyst. Although the latter series is not discussed in this paper, the results of analysis are included for comparison.

The most interesting result of the analyses from the point of view of this paper is the ash content of the peat, the surface samples of both series having a higher percentage than the deeper samples. The much greater percentage of ash in the surface samples results in part from repeated burning, which leads to the concentration of ash at the surface. This concentration tends to make the peat more friable, and so forms a better bed for manuka and gorse seeds, than the original peat surface.

The pH of samples from different areas was determined to discover if possible any relation between pH and the existing plant community. The results, with comments on the most recent effects of biotic factors upon the plant communities are presented in Table II below.

TABLE I. ANALYSES OF PEAT FROM PAEKAKARIKI-PARAPARAUMU AREA
(COAL SURVEY SAMPLES, C.S. 3952-3958)

Location of Peat	Depth (m)	Wt.loss on Air-drying (%)	Proximate Analysis based on Air-dried Peat						Wax extracted by Benzol + (%)
			Moisture (%)	Volatile matter (%)	Fixed Carbon (%)	Ash (%)	Sulphur (%)	Calorific Value (B.Th.U. per lb)	
South of Poplar Avenue									
Sample C.S. 3952	0.00-0.05	-	10.9	32.4	19.6	37.1	0.1	4,900	
3953	0.05-0.10	78.5	12.9	53.8	25.1	8.2	0.2	7,240	
3954	0.20-0.25	83.1	14.6	52.5	29.9	3.0	0.2	7,180	3.0
3955	0.45-0.50	80.7	39.8	40.3	18.6	1.3	0.3	5,570	
Half-Mile North of Poplar Avenue									
Sample C.S. 3956	0.00-0.15	65.2	17.9	44.0	25.9	12.2	0.7	6,330	
3957	0.20-0.30	76.6	13.1	53.8	31.1	2.0	0.9	8,140	3.6
3958	0.40-0.50	72.2	23.6	47.2	25.9	3.3	0.2	7,520	

+ Composite samples were prepared from each locality and wax estimated by soxhlet extraction with benzol.

TABLE II. pH VALUES OF PEAT SAMPLES FROM AREAS C_3 - F_4 SHOWING THE PRESENT PLANT COMMUNITY ON EACH AREA.

Area	Depth (cm)	pH	Plant Community	Recent Effects of Biotic Factor
C_3	0-9	4.3	Manuka *Gleichenia circinata*	High water-table resulting from drainage impeded by road embankment
C_3	0-10	4.5	Manuka *G. circinata*	" "
D_1	Broken monolith	4.2	Bracken (*Pteridium esculentum*)	Recent fire. Plant community regenerating
D_1	0-10	4.7	Bracken (*P. esculentum*)	" "
D_3	0-6	4.3	Manuka *G. circinata*	Destroyed by fire. High water-table.
D_3	0-7	5.4	Manuka *G. circinata*	" "
E	Broken sample	5.3	Established pasture on consolidated peat	Grazed by cattle
F_2	Broken sample	4.4	Pasture	Apparently recently reclaimed
F_3	0-10	6.6	Recently established pasture	Heavily topdressed
F_3	0-10	6.7		
F_4	0-10	4.4	Abandoned after recent stumping	

Although there is now a considerable range in pH, it is likely that under primitive conditions, the range was somewhat narrower, as then the vegetation and peat would be developing under more uniform conditions.

The conclusions drawn from the above table can be briefly summarized:—

(1) As a result of unequal burning, and the consequent formation of hummocks, peat from localities in close proximity to each other can have an appreciably different pH.

(2) The wetter areas and the peats dominated by bracken communities are generally strongly acid.

(3) Although the plant communities show a general relationship to pH, it would appear that their present distribution is attributable more to the interaction of biotic factors than to the direct influence of pH.

VEGETATION

Primitive Vegetation

It is impossible to describe the primitive plant association, but an indication of the composition of at least part of the forest element can be given as half the 22 wood samples collected have been identified (Table III).

As several of the specimens forwarded to the New Zealand Forest Service were root wood, it was not possible to identify these with any certainty and they are included in the above table as *Podocarpus* spp., *Podocarpus* sp. or *Dacrydium* sp., and Myrtaceae. (Personal communication from R. Orman.)

TABLE III. SPECIES OF TIMBER SAMPLES COLLECTED BETWEEN McKAY'S CROSSING AND PARAPARAUMU

Name	Number Collected	Area on which collected
Podocarpus dacrydioides (Kahikatea)	2	E; G.
P. spicatus (Matai)	2	A*; D.
P. totara (Totara)	3	A; H(2)
Podocarpus spp.	3	A; C; G.
Podocarpus sp. or Dacrydium sp.	3	F(2) G:
D. cupressinum (Rimu)	2	D(2)
Laurelia novae-zealandiae (Pukatea)	2	G; H.
Myrtaceae	5	A; C; D(2);G.

* Area A is at McKay's Crossing and is not discussed here.

The table shows clearly the predominance of Podocarps, suggesting that the primitive association was in part a Podocarp forest. A mixed forest of the above species is visualized, each species occurring wherever local edaphic conditions permitted. Pukatea and members of the Myrtaceae were probably scattered throughout. Manuka and possibly *Eugenia maire* (maire) probably represented the Myrtaceae.

The greater density of stumps in the marginal and shallower peats, suggests that the forest species were denser in that portion than in the central and deeper portions of the peat area, which were probably covered by manuka and other more characteristic bog vegetation, including *Sphagnum* sp., and *Gleichenia circinata*.

Induced Plant Communities

Six plant communities have been distinguished, the first four representing some stage in regeneration after the effects of fire:—

(1) Bracken-manuka-gorse community.
(2) Manuka community.
(3) Bracken community.
(4) Gorse community.
(5) Swamp community.
(6) Pasture.

A number of plants are common to all or some communities, characteristic species being *Anthoxanthum odoratum* (sweet vernal), *Holcus lanatus* (yorkshire fog), *Hypochacris radicata* (cat's ear), *Haloragis micrantha, Rumex acetosella* (sheep's sorrel), *Trifolium repens* (white clover) and *T. dubium* (suckling clover). Sheep's sorrel is characteristic of less consolidated peats.

Bracken-Manuka-Gorse Community

A characteristic of this community is its fairly open aspect. Bracken and manuka develop more rapidly than gorse, as stock graze gorse seedlings and so hold it in check. As manuka is occasionally cut down, bracken is generally the dominant species.

The bracken forms small but dense and closely spaced clumps, rarely more than 1.5 m high. Occasional dense clumps of gorse are present, while short manuka is scattered throughout. In depressed and locally damp areas, such species as *Polytrichum* sp., and *Haloragis micrantha* occur. *Juncus lampocarpus* is also occasionally present. *J. pallidus* occurred sparingly in one small corner of this community.

Manuka Community

Manuka is found over the entire area, except for those completely reclaimed peats now used for dairying. It is dominant, however, on only a small part of the area to-day. This community falls into two groups, each determined by the relative height of the water-table.

The first is found locally where the water-table level is high. It is not a primitive community, but as *G. circinata* has been more widely distributed over the area than at present, this community may represent a reversal to a developmental stage of the primitive plant community. Bracken has been common, but is now almost completely dead except along the drain banks and drier parts near the Poplar Avenue embankment.

The community has a patchy appearance because of the cutting down of manuka and the recent development of seedlings. The community as a whole is fairly open, but the ground layer is being rapidly invaded by *G. circinata,* which is growing through dead bracken litter and around the base of manuka plants.

Other species present were *Drosera binata, Haloragis micrantha, Centella uniflora* and young plants of *Cladium teretifolium. Sphagnum* sp. occurs in wet depressions, while in a small zone flooded to a depth of 8 cm it was dominant, with *G. circinata* sub-dominant. Wherever the surface was slightly raised and drier, introduced weeds and grasses were present.

In the second a stand of manuka was dominant on a small portion of the area only. The plants grew close together and were over 2 m high.

A mixed community of manuka in which gorse occurred was so dense that all other species were excluded, except along the margins of the community. Isolated gorse plants were present and near the inner boundary of this community it was sub-dominant to manuka. This represents the most stable community on the area.

Bracken Community

With the exception of the completely reclaimed peats, bracken is common, but is dominant over only a small area. The bracken forms a comparatively dense cover, and is characteristic where a hummocky surface has resulted from the burning of the peat. Gorse seedlings are present, and these, together with an occasional dead and charred gorse plant indicate that previously the area supported at least a bracken-gorse community.

Gorse Community

Gorse is dominant and is the only species present, where this community occurs near Paraparaumu Road, except for a few grasses and weeds in the more open marginal belt. *Blechnum procerum* and *Drosera binata* occur on the sides of the drain. In deeply burnt pits, bracken is also present.

Some parts of Area D which are dominated by gorse have bracken in association. This community is also very dense. Bracken has its greatest development along the drain side, and in pockets throughout the community.

Swamp Community

This community forms a narrow belt running parallel to the main highway and is well developed for a short distance on both sides of Poplar Avenue, and ends less than a quarter of a mile north of Poplar Avenue.

Species present were *Typha angustifolia* (Raupo), *Phormium tenax* (*Phormium*), *Carex virgata, Juncus lampocarpus, Epilobium pallidiflorum* and *Cladium teretifolium.* Raupo was not dominant, while *Phormium* was dense only in the drier zone where the community ended at a small sand dune.

This community is probably present as a result of the high mineral content of the peat which is watered by streams from the adjacent hills.

Pasture

Pasture covers a considerable portion of the peat, and is used for dairying.

The pasture is in general composed of *Lolium perenne* (perennial rye-grass) and *Trifolium repens* (white clover). Where the pasture has been only recently established, *Poa annua* is present, and *Holcus lanatus* (yorkshire fog) and *Anthoxanthum odoratum* (sweet vernal) appear occasionally throughout the area in pasture. *Ranunculus repens* (creeping crowfoot), *Juncus lampocarpus* and *Polygonum* sp. enter the community wherever the peat surface is depressed and moist.

Festuca arundinacea (tall fescue) and occasionally *Dactylis glomerata* (cocksfoot) are seen in some paddocks which appear to have been neglected.

A characteristic rush species on the reclaimed peats is *Juncus polyanthemos,* which was calculated to cover 5 per cent of the peat surface on the peats which have been reclaimed for some time and are consequently well consolidated. On recently reclaimed peats which are in pasture but not yet well consolidated rushes are absent.

DEVELOPMENT OF INDUCED COMMUNITIES

As the primitive association has been completely destroyed, and as there is no secondary succession to the edaphic climax, no account of the primary succession is possible, except by studying peat and pollen analysis, which is outside the compass of this paper. Nevertheless, from the complex of induced plant communities mainly controlled by the biotic factors, a development from one community to another does occur. Most of the communities present have resulted from uncontrolled use of fire, but the pasture community indicates that with care, the peat can be reclaimed at least for dairying.

With the destruction of the primitive association it has been assumed that manuka became much more widespread and that bracken also became more frequent as drainage began to take effect. Gorse, early naturalized in New Zealand (Allan, 1940) would slowly spread across the peat from the centre of its first introduction.

From the available evidence, fire is the most powerful factor controlling the development of the plant communities. A severe burn destroys all vegetation. On the bare peat manuka and bracken develop vigorously, replacing the pioneering plants such as the moss *Campylopus introflexus* and sheep's sorrel. Grasses and white clover enter this open community, and where the surface is hummocky, the thin pasture develops best between the hummocks. With repeated burning a bracken community can develop as the rhizomes are not so readily damaged by fire.

So long as the peat is not burnt to the water-table level, gorse is able to spread especially after the manuka-bracken, or bracken community has been opened by fire. If the gorse develops undisturbed, it rapidly becomes dominant and so dense that other species are unable to enter the community. Once a gorse community is well established, fire may destroy the existing plants, but they will be rapidly replaced by plants grown from germinating gorse seeds.

The development of plant communities as outlined above is retarded to a certain extent by the grazing of stock. Thus if a manuka community is replaced by bracken, gorse will develop slowly even after repeated burning, as stock graze gorse seedlings quite readily. In this way a bracken-manuka, or bracken, community can continue almost indefinitely. But with continued trampling by stock, the peat surface already consolidating as a result of drainage becomes firmer and a thin cover of grass and weeds becomes established. This cover gradually becomes more dense, so long as fire does not enter the community.

Drainage too plays a part in the development of the induced plant communities. Bracken enters the community when drainage is initiated, but with continued draining and grazing by cattle, the peat surface can become sufficiently consolidated and dry to permit the establishment of a comparatively good pasture. Good management would ultimately lead to reclaimed peat supporting a dense sward suitable for dairying. Fire would retard this process.

Too rapid draining causes the surface peat to dry quickly. It crumbles and becomes powdery, with the result that lateral movement of water is prevented whilst moisture cannot be drawn by surface evaporation from the wet peat below. The final result is that a very dry crumbly peat overlies stagnant peat, which inhibits the development of a good pasture.

If the water-table should rise, after drainage has been initiated, due to local blocking of the drainage system, the induced community will revert to a partly primitive community. A bracken-manuka community has been replaced by a manuka-*Gleichenia circinata* community, in which *Sphagnum* sp. occurs, on a local area where the drainage has been partly blocked, and which is a more typical bog vegetation than seen on other parts of the peat.

As an area is reclaimed and a pasture established, weeds such as rushes which are difficult to eradicate can enter the community. If a firm turf is present, and the area not overstocked, rushes, if absent, may not easily enter the community.

From the first induced plant community, various stages of development can be initiated. Depending upon management the peat can be reclaimed to useful farm land, or it can develop into waste land of no economic value. Both lines of development are illustrated in Fig. 3 which summarizes the development of the area.

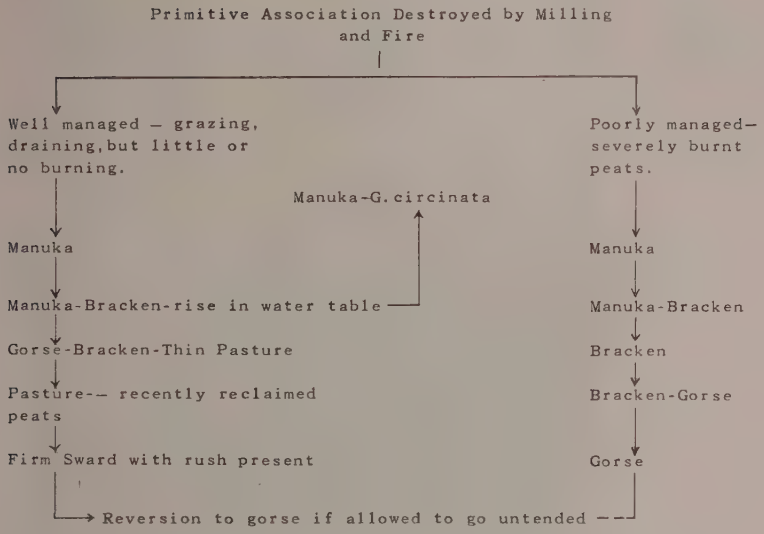

Fig. 3 Diagrammatic Summary of the Development of the Plant Communities on the Area Investigated.

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CODLING MOTH INVESTIGATIONS IN NELSON, 1948-49

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(*Received for publication, 28 February 1951*)

Summary

1. The bait-trap catches of moths vary more or less with the evening temperature. This correlation may be upset by other factors such as rain.
2. The first moth was taken on 31 October and the last on 14 March. There were two peak catches of moths during the season, one between 9 December and 17 December, and the other reaching its maximum on 31 January. This corresponds with the bait trap catches carried out in 1931-32 when two peaks were also encountered. These two peaks are probably due to the fact that weather conditions caused fluctuations in moth emergence.
3. A comparison shows that the time of emergence of the moths varies each season. In 1925, the maximum catch was from 2 to 7 December; in 1931, it occurred from 17 to 24 November; and in 1948 from 9 to 17 December.
4. In well separated areas of the Nelson district, the moth flight periods were found to coincide.
5. The number of moths caught in bait traps gives no indication of the population in an orchard. Winds and cool evenings possibly retard moth flights.
6. Male and female moths were trapped in equal numbers during the peak of the second flight.
7. On 23 December, 1948, it was found that 15·6 per cent of the young apples were infested, and that 66·7 per cent of the larvae were 1st instar and the rest 2nd and 3rd instars.
8. The first larvae of 1948-49 season migrated into the bands between 5 and 14 January.
9. There was no second generation during this season.

INTRODUCTION

THE following investigation was carried out with the intention of ascertaining the flight period of the codling moth and the date of initial infestation of the apples in the Nelson district. For this purpose, moths were trapped in three separate areas; two of these were commercial orchards situated at Stoke and Mapua, and the third a derelict orchard at Hira. The orchards at Hira and Mapua were situated approximately 10 and 20 miles in opposite directions from the Stoke orchard. At the same time, samples of apples were taken from the trees at Hira to ascertain the percentage of infestation and the growth of the larvae. About 50 trees were banded at Hira and Stoke, and from these larvae were obtained for laboratory experiments and possible evidence of a second brood.

In 1931-32 Dumbleton carried out a similar piece of work in Nelson, and the results obtained for this season are compared with his. In U.S.A. and South Africa, prolonged investigation has already been carried out relating to the flight periods of the codling moth and to its habits and life history.

EXPERIMENTAL METHOD

Ten bait traps were placed in each of the orchards at Mapua and Hira, and 20 in the one at Stoke. The traps consisted of a painted six-pound jam tin (Fig. 1) with a wire handle, which slipped over a hook placed as near the top of the tree as possible, with a clear space above the tin. The tins hung 7-10 ft. above the ground.

FIG. 1.—Bait tin suspended in apple tree at Stoke.

The bait used was a mixture adapted from one of the most effective baits used in the United States (Bobb, Woodside, Jefferson ; 1939). The solution consisted of 1 pt. of molasses to 20 pt. of water and oil of aniseed mixture (aniseed, 30 ml.: water, 168 ml.: and bentonite, 6 g.) at the rate of 77 ml. per quart of solution. Occasionally a small amount of yeast was used to start fermentation. In order to keep the traps at a more or less uniform degree of attractiveness, it was found that if half the old bait was retained in the tin, and the new solution added to it, better results were obtained than with a totally fresh solution. A teaspoon of brown sugar was added to each tin once a week. It was found that the new fermenting solution was not attractive to the moths during the first two or three days.

At Stoke, a block of Dunn apple trees was selected and the tins placed in every third tree. At Mapua, the tins were hung at random in a small block of Cox's Orange, and at Hira, throughout the orchard which consisted of 20 trees of mixed varieties.

In January, 1948, 56 Dunn trees were banded at Stoke, and the larvae used for laboratory rearing the following season. In December, 1948, 24 trees further along the block of Dunns were again banded, and also the whole of the orchard at Hira. The bands used were strips of ordinary hessian sacks cut 8 in. wide, folded double, and wrapped around the trunk of the tree with the opening of the fold downwards.

The overwintering larvae were placed in wooden racks consisting of a series of cells. These racks were similar to the ones used in a previous study of the Moth (Hamilton, 1934).

In the orchard at Stoke, a thermohygrograph was set in a box which was shaded from the sun and placed in an apple tree. Wind velocity and rainfall were recorded at the aerodrome situated about 1½ miles from Stoke.

Field Observations

Bait Trap Catches

In the Stoke orchard, the catches were good. These were correlated with the evening temperatures and the humidity on each day from 25 November, 1948, until 13 February, 1949. It had already been found from studies made overseas, that the extent of the moth flights was influenced by evening temperature, humidity, light intensity, and air currents.

Temperature

The mean daily temperature taken at 5, 7 and 9 p.m. was considered in conjunction with the moth catches (Fig. 2). A similar comparison was made by Dumbleton during the 1931-32 season (Dumbleton, 1932).

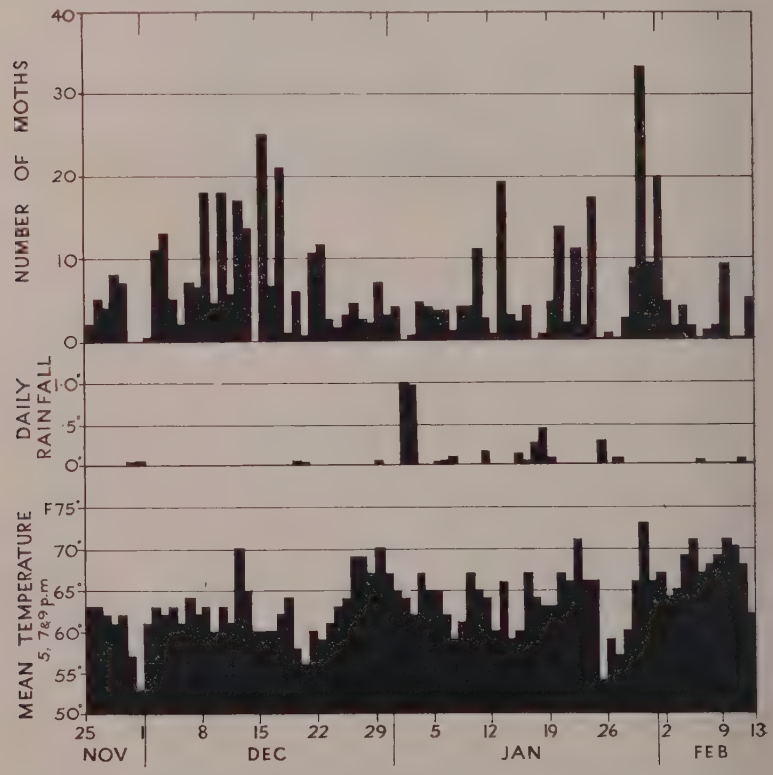

FIG. 2.—Graph showing the daily mean evening temperature and rainfall together with the number of moths taken in the bait traps.

It has been found (Nel, 1940) that the maximum flight of moths takes place within half an hour before and after sunset. However, the mean temperature records taken 2 hours around sunset, consistently averaged 2-3°F. less than the mean of those taken at 5, 7 and 9 p.m. Therefore, in order to compare this investigation with the previous one, the mean temperature at 5, 7 and 9 p.m. is used. When the moths were retained in the laboratory, they became active between 4 and 5 p.m.

The relationship between the daily mean temperature and moth catches, is similar to the results found in the 1931-32 survey (Dumbleton, 1932). There is some correlation between temperature and moth catch, but it is most noticeable where a sharp rise or fall in temperature occurs. The largest catches of moths were obtained between 60° and 73°F. During late December and early January, there were temperatures over 60°F. but the moth catches were poor.

Humidity, Rainfall and Wind

The humidity readings taken in the orchard gave no correlation with moth catch. The average humidity for this district is about 75 per cent and the temperature does not fall rapidly with rain. There was an inverse relationship between the daily rainfall and the moth catch. The evening wind-speeds showed no correlation with moth catch, but this may be due to the station recording sea breezes that did not reach the orchard.

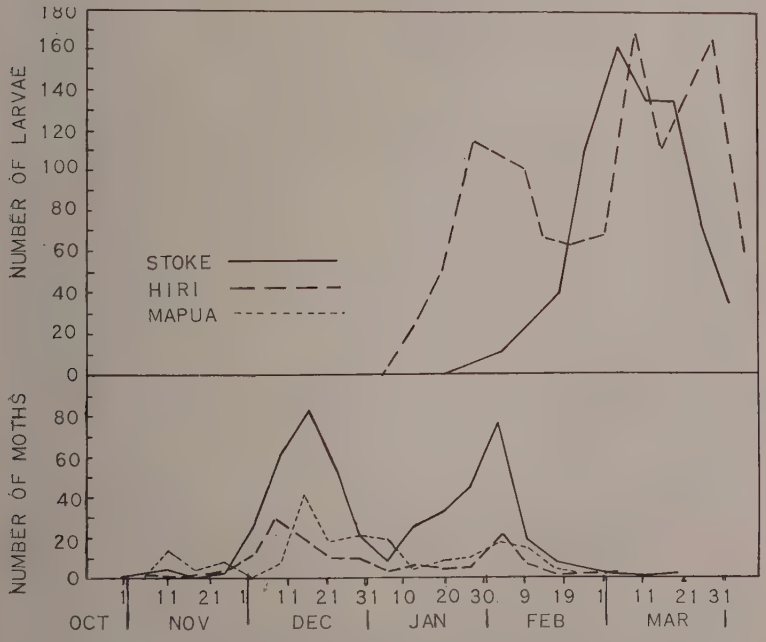

FIG. 3.—Graph showing the correlation in bait trap catches of moths at Stoke, Hira and Mapua with the two peaks of flight. The upper graph shows the weekly collection of larvae from banded trees.

Comparison of Moth Activity at Stoke, Hira and Mapua

The weekly catch of moths during the flight period at Stoke, Hira and Mapua are shown in Fig. 3. The period of flight of the moths shows a distinct similarity in the three areas. The first moths were collected during the week ending 5 November and the main flight ended the last week in February. The three graphs show two peaks of flight, the first taking place from 9 to 16 December and the second from 27 January to 3 February. This data shows that the peak flights of the moths coincide in the different apple-growing areas of the Nelson district.

In this investigation of 1948-49, there is a distinct drop in moth catches in late December and January. This may possibly be due to weather conditions, for there was heavy rain on 2 and 3 January followed by periodic rain and a fall in temperature during the next two weeks. However, Dumbleton also recorded a similar drop in the moth catch which occurred during a period of rough weather. Another factor that will influence the bait-trap catches is the time of emergence of moths in the field. According to South African and American investigations, there are waves of moth emergence with short periods of heavy emergence (Nel, 1940, p. 66).

Variation in Size of Moth Catch

The traps and bait used in the three orchards were all identical. However, the numbers of moths caught at Hira and Mapua were well below those obtained at Stoke (Fig. 2). As the spray schedule had been carefully followed at Mapua, but only spasmodically at Stoke, a lower moth population would be expected at Mapua. The orchard at Hira was old and neglected, and a very large catch of moths should have been obtained. When the apples matured, a large percentage showed codling-moth damage, so there must have been numerous ovipositing females present. The reason for a light catch probably lies in the situation of the Hira orchard, which being in a valley enclosed by hills, is subject to cool evening temperatures and strong winds. These two factors probably account for the moths not coming readily into the traps.

Comparison of Catches during 1925, 1931 and 1948

When the time of occurrence of the first moth and the first maximum peak of catches in the traps are compared for three different seasons, the result shows a variation in the time of emergence. Table I which summarises the dates of moth emergence in the 1925, 1931 (Dumbleton, 1932), and 1948 seasons indicates that there is about three weeks difference in the time of maximum emergence in 1931 and 1948.

TABLE I. VARIATION IN TIME OF MOTH EMERGENCE DURING THREE SEASONS

Year.	Date First Moth Trapped	Peak Period (First) of Moth Flight
1925	29 Oct. 15 Nov.	2 - 7 Dec.
1931	—	17 - 24 Nov.
1948	31 Oct.	9 - 17 Dec.

This is comparable with the evidence published by Cutright (1937), where a series of trappings were carried out over a period of 10 years and the time of peak catch was found to vary according to the weather from April onwards.

Sex Ratio of Trapped Moths

When the large catches of the second peak of flight were obtained, the male and female moths were trapped in equal proportion. According to results obtained from previous investigations, anethol is supposed to be an ovipositional attractant (Dethier, 1947, p. 68).

Early Infestation of Apples

At the Hira orchard, 48 apples were picked each week from 12 apple trees. The first selection was made on 23 December, and the last on 20 January (Table II) as the early apples began to fall by this date.

TABLE II. PERCENTAGE OF INFESTED APPLES AND LARVAL INSTARS RECOVERED FROM APPLES

Date	Apples infested (%)	Stage of Development of Larvae.				
		1st instar (%)	2nd instar (%)	3rd instar (%)	4rh instar (%)	5th instar (%)
23/12/48	15·6	66·7	16·7	16·7	—	—
30/12/48	16·7	37·5	50·0	12·5	—	—
6/ 1/49	29·2	6·7	66·7	26·7	—	—
12/ 1/49	35·4	14·3	21·4	50·0	7·1	7·1
20/ 1/49	43·8	5·9	17·6	35·3	29·4	11·8

The apples were taken at random from each tree, and the results were comparable each week, since the number of samples was constant i.e. five and three apples were removed from trees bearing good and average crops respectively.

On 23 December only 15·6 per cent of the apples were infested. Of the larvae infesting these apples, 66·7 per cent were 1st instar and the rest evenly divided between the 2nd and 3rd instars. However, by 20 January about half the apples were infested, and the majority of larvae obtained were of the 3rd and 4th instars.

Field Collection of Larvae

Over-wintering Larvae 1947-48 Season

A few trees were banded at Hira and Stoke in January 1948, and the bands removed in October 1948. Pupae were found from 6 to 15 October but only averaged 3 to 5 per cent of the total number of larvae plus pupae. During the two weeks 18 November to 12 December about 10 per cent had pupated. This is merely an indication of the rate of pupation, since the warmth of the sun does not penetrate the bands as readily as the bark. It also appears as if the larvae may leave the bands and seek more convenient places for spinning cocoons.

Larvae of 1948-49 Season

Apple trees were banded on 14 December, 1948, and these consisted of 19 trees of mixed varieties at Hira, and 24 Dunn's at Stoke. The bands were removed once a week. The first larvae migrated into the bands at Hira between 5 and 14 January, while at Stoke they appeared during the period 20 to 26 January (Fig. 3).

Second Generation Moths

From 14 January to 28 February, 1949, about 900 caterpillars were taken from the banded trees and placed in racks in the insectary. All the larvae overwintered as larvae; thus none pupated and produced a second brood of adults. The same fact was found by Dumbleton in 1930-31. Elsewhere in New Zealand, during codling moth investigations a small second brood has been recorded. In Canterbury during 1931-32 (Hamilton, 1934), 1·73 per cent of the larvae collected developed as a second brood. The reason for only one generation in Nelson may be the low mean tempergture and high humidity of this district, as compared with other areas of periodic high summer temperatures and lower humidity.

Laboratory Investigations

Length of Pupal Period

Under insectary conditions the length of the pupal period was found to vary from 30 to 16 days, the time decreasing as the season advanced. The average length of the pupal stage for the months October, November, December and January were found to be 29, 25, 19 and 20 days respectively.

Pre-oviposition Period

The first copulation of the moths takes place 2-3 days after emergence. In the insectary the majority of moths mate 30-45 minutes after sunset and stay in copulation for 1-1¼ hours. In the orchard where the light intensity would exceed that of the insectary it is possible that mating takes place slightly later.

The moths in captivity remain quiescent all day until about 4 hours prior to sunset, but become very active only during the two hours before sunset.

Egg-laying

Egg-laying begins 1-2 days after mating and spreads over a period of 1-15 days. The majority of eggs are laid during the first 3-7 days. In captivity the moths laid 1-129 eggs with an average of 40·8 per moth.

In captivity the male moths lived about 2 weeks and the females 2-3 weeks.

Length of Egg Stage

The egg stage lasts 8-11 days with 33 and 51 per cent of the larvae hatching in 9 and 10 days, respectively.

Pupation and Emergence in Insectary

There was only one peak of pupation and emergence under insectary conditions. Under natural conditions the emergence of moths is supposed to occur over a period of two months. The first pupation took place on 20 October, and the maximum number pupated during the first two weeks in December.

The first moth emerged on 5 November, and the maximum emergence took place during the last week in December and the first week in January.

ACKNOWLEDGMENTS

The author is indebted to Mr. L. J. Dumbleton for his advice and criticism during the carrying out of the project ; to Mr. J. S. Timlin for his assistance in trapping the moths ; to Mr. A. W. Parrott who suggested the sampling method used for obtaining the infestation of the apples ; and to members of the Entomological Research Station Staff who helped periodically with the work.

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SPRAY TREATMENTS FOR CONTROL OF LEAF ROLLER (*Tortrix Postvittana* Walker) IN APPLE ORCHARDS

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(*Received for publication, 12 December 1950*)

Summary

Following reports from the Nelson district of increased infestation by leaf roller (*Tortrix postvittana* Walker) in apple orchards where DDT had been used in place of lead arsenate, field trials on control were carried out which showed :

1. That DDT, 8 oz. p,p′ isomer to 100 gal. water was less effective than lead arsenate 1½ lb. to 100 gal. water.
2. The use of lead arsenate 1½ lb. to 100 gal. water followed by DDT 4 oz. p,p′ isomer to 100 gal. water from late December onwards was inadequate where leaf roller infestation was severe.
3. Good commercial control was obtained with lead arsenate 1½ lb. to 100 gal. water used at normal intervals throughout the season.

Because of fruit and foliage injury known to be associated with the use of lead arsenate, alternative materials for control were investigated. DDD, 4 oz. technical to 100 gal. water, gave control of leaf roller comparable with that from lead arsenate 1½ lb. to 100 gal. water. The most effective time for spraying with DDD was found to be immediately following petal-fall. Parathion was also shown to be highly efficient in leaf roller control, being comparable in performance with DDD when used at similar dosages.

Introduction

Leaf roller attack in apple orchards has for many years been severe in the Nelson district, but comparatively of little importance in Hawkes Bay and Auckland. With the introduction of DDT in place of lead arsenate into the spray programme for control of codling moth (*Cydia pomonella* L.), growers reported increased difficulty in leaf roller control. Most of these reports came from the Nelson district, and more particularly from growers who used DDT sprays throughout the season instead of following the recommended procedure of restricting the use of DDT to the period from January onwards. In view of these reports experiments were carried out to determine the relative efficiency of DDT and lead arsenate against leaf roller, and to investigate alternative means of control.

Experimental Methods

All treatments were applied to orchard trees by conventional spraying methods using twin nozzles on a 6-ft lance, operated at a nozzle pressure of 350 lb. per square inch and delivering approximately 3·5 gal. per minute. Trees of the varieties Jonathan, Dunns Favourite and Sturmer were used in the trials, because of their known susceptibility to leaf roller. Two or more trees were included in each plot. Treatments were randomised within blocks and each block was replicated at least three times.

The following spray materials were used :—

Acid lead arsenate : Wettable powder with at least 90 per cent of particles less than 10μ in diameter and water solubility less than 0·2 per cent as arsenic pentoxide.

DDT: Wettable powder with 95 per cent of particles passing 300-mesh British standard sieve. Dosage rates expressed in terms of p, p′ isomer of DDT.

DDD (Dichloro-diphenyl-dichloroethane): Wettable powder with 95 per cent of particles passing 300-mesh British standard sieve. Dosage rates expressed in terms of technical DDD.

Parathion: Wettable powder containing 15 per cent parathion and 85 per cent inert clay. Dosage rate expressed in terms of 15 per cent wettable powder.

All treatments were combined with the sulphur sprays normally used in commercial practice. Where lead arsenate was used, hydrated lime, 3 lb. to 100 gal., was included in the mixture.

Records were taken from windfalls and from the harvested crops, and are shown as percentage fruits damaged by leaf roller. Statistical analysis of results was carried out directly on the percentage figures, and where differences between treatments were large, on the equivalent angles.

TABLE I. DDT COMPARED WITH LEAD ARSENATE FOR LEAF ROLLER CONTROL ON JONATHAN APPLES: NELSON, 1947/48 SEASON.

Quantity insecticide per 100 gal	Dates of application	Percentage fruit damaged by leaf roller	Equivalent angles
1. Lead arsenate 1½ lb	1 and 20 Nov., 8 and 29 Dec., 28 Jan. and 11 Feb.	9.4	17.4
2. DDT 4 oz	As for Treatment 1.	27.4	31.1
3. Lead arsenate 1½ lb DDT 4 oz	1 and 20 Nov. and 8 Dec. 29 Dec. 28 Jan. and 11 Feb.	19.9	26.3
4. Check	-	38.8	38.9
Difference for significance at 5%		-	2.7

TABLE II. DDT COMPARED WITH LEAD ARSENATE FOR LEAF ROLLER CONTROL ON DUNN'S FAVOURITE APPLES: NELSON, 1947/48 SEASON

Quantity insecticide per 100 gal	Dates of application	Percentage fruit damaged by leaf roller
1. Lead arsenate 1½ lb	7 and 20 Nov. 8 and 29 Dec. and 21 Jan.	3.9
2. DDT 4 oz	As for Treatment 1	13.3
3. Lead arsenate 1½ lb DDT 4 oz	7 and 20 Nov. and 8 Dec. 29 Dec. and 21 Jan.	5.9
4. Check	-	24.6
Difference for significance at 5%		3.0

RESULTS

Comparative Efficiency of DDT and Lead Arsenate

Nelson 1947/48 season : Results given in Table I are from a trial on the Jonathan variety. Lead arsenate, 1½ lb. to 100 gal. proved much superior to DDT, 4 oz. to 100 gal., in leaf-roller control. Where lead arsenate, 1½ lb. to 100 gal., was used up to 8 December, followed by DDT, 4 oz. to 100 gal., in later sprays, significant improvement in control was secured in comparison with DDT alone, but leaf-roller damage still remained much higher than where lead arsenate was used throughout the season.

Nelson 1947/48 season : Results of a trial similar to above, but on the variety Dunns Favourite are given in Table II. DDT again failed to give control of leaf roller comparable to that secured with lead arsenate The use of lead arsenate up to 8 December, followed by DDT later in the season gave much better control than DDT alone. Results differed from the previous experiment in that DDT followed by lead arsenate showed only a small and non-significant increase in leaf-roller damage compared with the use of lead arsenate throughout the season.

Comparative efficiency of DDT, lead arsenate plus DDT and DDD

Nelson 1948/49 season: In Table III results from a series of treatments applied to the Sturmer variety again show the inadequacy of DDT, 4 oz. and 8 oz. to 100 gal., for leaf-roller control. The use of DDT at 2 oz.

TABLE III. DDT AND DDD COMPARED WITH LEAD ARSENATE FOR LEAF ROLLER CONTROL ON STURMER APPLES: NELSON, 1948/49 SEASON.

Quantity insecticide per * 100 gal	Percentage fruit damaged by leaf roller	Equivalent angles
1. Lead arsenate 1½ lb	7.5	15.3
2. Lead arsenate 1½ lb plus DDT 2 oz	5.7	13.5
3. Lead arsenate 1½ lb plus DDT 4 oz	4.8	12.1
4. DDT 4 oz	29.8	32.7
5. DDT 8 oz	10.3	23.4
6. DDD 8 oz	0.6	3.6
7. Check	58.4 **	-
Difference for significance at 5%	-	5.1

* Application dates for all treatments were 19 Nov. and 29 Dec., 8th Jan. and 10 Feb.

** Check treatment not included in analysis of variance.

and 4 oz. combined with lead arsenate at 1½ lb. to 100 gal. failed to show a significant improvement in control compared with lead arsenate alone. DDD, 8 oz. to 100 gal. gave results much superior to those from any other treatment.

DDD at different dosages and periods of year compared with lead arsenate and parathion

Nelson 1949/50 season: Treatments and results of an experiment on the Jonathan variety are given in Table IV. DDD at dosage rates of 4-8 oz. to 100 gal. (Treatments 3 and 4) gave control of leaf roller comparable to that secured with lead arsenate, 1½ lb. to 100 gal. (Treatment 1). Parathion 15 per cent. wettable powder, 8 oz. to 100 gal. (Treatment 5) gave results inferior to lead arsenate, but the difference was not significant. The parathion treatment gave results comparable with DDD, 4 oz. to 100 gal. (Treatment 3). It was inferior to DDD, 8 oz. to 100 gal. (Treatment 4), and superior to DDD, 2 oz. to 100 gal. (Treatment 2), although in the latter comparison the difference in percentage of leaf roller damage was not significant. Where DDD was used at successively later periods in the season, results show that the most effective control was secured by the sprays applied immediately after petal-fall (Treatment 6). A significant increase in leaf-roller damage occurred where treatments were applied in December (Treatment 7) with a further significant increase where the date of application was delayed until the January to February period (Treatment 8).

TABLE IV. DDD AT VARIOUS DOSAGES AND DATE OF APPLICATION COMPARED WITH LEAD ARSENATE AND PARATHION FOR CONTROL OF LEAF ROLLER ON JONATHAN APPLES: NELSON, 1949/50 SEASON.

Quantity of insecticide per 100 gal	Dates of application	Percentage fruit damaged by leaf roller
1. Lead arsenate 1½ lb	4 and 18 Nov., and 21 Dec. 14 Jan. and 11 Feb.	6.2
2. DDD 2 oz	"	13.0
3. DDD 4 oz	"	8.7
4. DDD 8 oz	"	3.7
5. Parathion 15% wettable powder 8 oz	"	9.2
6. DDD 8 oz	4 and 18 Nov.	8.2
7. DDD 8 oz	2 and 21 Dec.	12.5
8. DDD 8 oz	14 Jan. and 11 Feb.	18.4
9. Check	-	51.9 *
Difference for significance at 5%		4.3

* Check treatment not included in analysis of variance.

Comparative efficiency of parathion and DDT

Hawkes Bay 1949/50 season: Results shown in Table V are from a trial on the Sturmer variety in which parathion was used over a wide range of dosages. Results show a progressive reduction in leaf-roller damage as the dosage rate was increased. All parathion treatments gave significant reduction in the percentages of leaf-roller damage compared with DDT, 4 oz. to 100 gal. No fruit or foliage damage was observed in any of the treatments.

TABLE V. PARATHION COMPARED WITH DDT FOR LEAF ROLLER CONTROL ON STURMER APPLES: HAWKES BAY 1949/50 SEASON

Quantity of insecticide per 100 gal	Dates of application	Percentage fruit damaged by leaf roller
1. Parathion 15% wettable powder 4 oz	19 Dec. 16 Jan. and 22 Feb.	8.2
2. " 8 oz	"	6.4
3. " 1 lb	"	3.9
4. " 2 lb	"	3.5
5. DDT 4 oz	"	12.9
6. Check	-	34.0 *
Difference for significance at 5%		2.6

* Check treatment not included in analysis of variance.

DISCUSSION

In a previous paper (Taylor 1951) it was shown that in view of the harmful effects to beneficial insects, dosage rates of DDT and numbers of applications should be kept to a minimum. It was demonstrated that for control of codling moth, 4 oz. DDT to 100 gal. was adequate, but as shown in the present paper, double this dosage is ineffectual for leaf roller control. Lead arsenate on the other hand gives commercial control of leaf roller but is less effective than DDT against codling moth. By employing lead arsenate in the post blossom period and introducing DDT from January onwards, adequate control of codling moth can be secured (*ibid*) and as shown in Tables I and II in the present paper, such a treatment would give improved control of leaf roller as compared with the use of DDT throughout the season. In the Nelson district, however, it appears probable that such a spray programme would still fail to meet commercial needs in relation to leaf-roller control, since results given in Table I indicate that considerable infestation may develop after mid-December. Under these conditions lead arsenate would be required throughout the summer with the addition of DDT from January onwards, where improved control of codling moth was required. This procedure, however, would not be a satisfactory solution to the problem, since fruit and foliage injury known to be associated with the use of lead arsenate (Taylor 1951) would still occur.

DDD is highly effective in the control of leaf roller. At a dosage rate of 4 oz. to 100 gal. water, it compares favourably with lead arsenate 1½ lb. to 100 gal. and is superior when used at 8 oz. to 100 gal. From results given in Table IV it is apparent that DDD applied in the immediate post blossom period is likely to be more effective than applications made later in the growing season. Before use can be made of DDD in commercial spray programmes, however, further work will be required to determine its effects on red mite populations and on woolly-aphis.

Results shown in Table V indicate that in control of the leaf roller parathion at comparable dosages is much superior to DDT and is equally as effective as DDD. It appears that parathion is unlikely to cause fruit and foliage injury. Parathion has the added advantage of contributing towards red-mite control (Taylor 1951), and from field observations is known to control leaf hoppers. The toxicity of parathion to mammals is known to be high, and in consequence there is a health risk both to the spray operator and to the consumer of sprayed produce ; the practical importance of this aspect is at present unknown.

Results of the present trials lead to the general conclusion that in orchards where leaf-roller infestation is of major importance, it is necessary to maintain a full programme of lead arsenate sprays. DDD and parathion are both of high potential value but require further investigation before their use is adopted in commercial practice.

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THE EFFECTS OF CHEMICALS AND ANTIBIOTIC SUBSTANCES ON CROWN-GALL (*Agrobacterium tumefaciens* (Smith and Townsend) Conn.)

PART IV.

By D. W. Dye, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

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Summary

Three antibiotic solutions, commercial streptomycin, 300 and 1,500 units per ml., and crude streptomycin, equivalent to 20 units per ml., and seven chemical solutions, methyl salicylate 20 per cent, acidulated merceric chloride 1 per cent, elgetol 2 per cent, " D.N.C. Winter Wash" 25 per cent, copper sulphate saturated solution, potassium dichromate saturated solution, and " Puratized " 50 per cent, were injected, smeared and brushed on marigold stems at time of inoculation with the crown-gall organism, and on growing galls on marigold plants.

When applied at time of inoculation all materials either prevented gall formation or greatly reduced the number of galls that developed.

When applied on growing galls, all except the three streptomycin solutions significantly retarded gall development and killed many galls. " Puratized ", which caused little plant damage, was the only material that gave complete control in both experiments. Similar control was obtained when copper sulphate and potassium dichromate were brushed and smeared on galls, but when injected into galls these materials killed the plants.

No one method of application was consistently superior to the other two.

Introduction

Previous experiments (Dye *et al.*, 1950 ; Dye, 1950) showed that of a number of materials used for control of crown-gall (*Agrobacterium tumefaciens* (Smith and Townsend) Conn), colchicine, dioxane, elgetol, iodine and clove oil were the most effective. As each of these has some disadvantage for practical use further experiments have been carried out. Included among the new materials tested were streptomycin and methyl salicylate.

Hampton (1948) reported that streptomycin would " cure " a variety of plants of crown-gall and Brown (1948) found that it killed tumour tissue in galls without influencing normal cells. Further, de Ropp (1948) found *in vitro* that streptomycin containing 500 units per ml. had an almost complete inhibiting effect on tumor formation if applied within 2 days of inoculation with the crown-gall organism.

Brown (1942) brushed full strength methyl salicylate on tumors of different ages on marigold plants, and found that if tumors were larger tham 1 cm. across they usually died.

Experimental Methods

French Marigolds (*Tagetes patula* L.) were grown in earthenware pots in a glasshouse at air temperatures between 60° and 80°F. When plants were approximately 3 in. high they were divided into two equal groups. One group (Experiment 2) was then inoculated using the method described by Dye *et al.* (1950) with a 24-hour beef-peptone-broth

culture of a virulent strain of *A. tumefaciens*. Thirty-six days later the other group (Experiment 1) was inoculated and plants in both groups were treated with the following materials :—

A. Streptomycin, supplied and assayed by Dr. T. R. Vernon, Plant Chemistry Laboratory, Department of Scientific and Industrial Research, Auckland, as follows :

I. Commercial streptomycin containing 300 units per ml.

II. Commercial streptomycin containing 1,500 units per ml.

III. Crude streptomycin equivalent to 20 units per ml. in a living broth culture of *Streptomyces griseus*.*

B. Methyl salicylate, 20 per cent. aqueous solution plus 1 per cent. Agral L (a proprietary wetting agent).

C. Acidulated mercuric chloride containing 1 part mercuric chloride dissolved in 2·5 parts concentrated hydrochloric acid and diluted with water to produce 1 per cent solution of mercuric chloride.

D. Elgetol (sodium dinitro-orthocresol), 2 per cent aqueous solution.

E. "D.N.C. Winter Wash" (a proprietary mixture of dinitro-ortho-cresol and petroleum oil), 25 per cent. aqueous emulsion.

F. Copper sulphate, saturated aqueous solution.

G. Potassium dichromate, saturated aqueous solution.

H. "Puratized" (a proprietary compound containing 5 per cent phenyl mercuri triethanol ammonium lactate), 50 per cent aqueous solution.

I. Water.

Three methods of application were used as described previously (Dye *et al.*, 1950), namely :—

1. Injection of the solution into the plants or galls.
2. Smearing of the inoculated area or gall with a lanolin paste containing the solution.†
3. Brushing of the solution on the inoculated stem or gall.

In Experiment 1 (Treatment at time of inoculation), each treatment was applied to six marigold plants, each plant having two inoculation points. In Experiment 2 (Treatment of growing galls) each treatment was applied to two 36-day-old galls on each of six marigold plants.

Results were determined by visible effects on galls and host plants, and by change in size of galls. In Experiment 1, plants were examined and galls measured 54 and 90 days after treatment. In Experiment 2, galls were measured the day before treatment and four times after treatment at approximately 14-day intervals.

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* Original culture obtained from Squibb Institute, United States of America.

† 30 ml. of each solution were mixed into 10 ml. crude lanolin except in the case of streptomycin III, methyl salicylate, elgetol and "Puratized" where 21·7 ml., 10 ml., 10 ml. and 15·5 ml. respectively were the maximum amounts that could be mixed into this quantity of lanolin.

RESULTS

Results are given in Tables I and II. The effect of treatments on growth rate of galls is shown in Fig. 1.

DISCUSSION

When applied at time of inoculation with the crown-gall organism, streptomycin II, acidulated mercuric chloride, copper sulphate, potassium dichromate and " Puratized " prevented gall formation at the points of inoculation while streptomycin I and III, methyl salicylate, elgetol, and " D.N.C." greatly reduced the number of galls that formed. Copper sulphate and potassium dichromate killed plants when injected into or brushed on stems, and caused slight to moderate damage when smeared on stems.

TABLE I. EFFECTS OF TREATMENTS APPLIED TO MARIGOLD STEMS AT TIME OF INOCULATION WITH A. TUMEFACIENS

Treatment		Effect of treatment on plants	No. of galls formed		Gall diameters in cm	
Material	Method of application		A. at 12 inoc.points all treated	B. at extra points not necessarily treated	Total growth of galls in 90 days after treatment *	Total Growth for Material *
Streptomycin I 300 units	Injected	No effect	1	0	0.30	4.66
	Smeared	"	9	2	3.89	
	Brushed	"	1	0	0.47	
Streptomycin II 1500 units	Injected	"	0	0	0	0
	Smeared	"	0	1	0	
	Brushed	"	0	0	0	
Streptomycin III Crude 20 units	Injected	"	0	0	0	1.62
	Smeared	"	2	2	1.62	
	Brushed	"	0	0	0	
Methyl Salicylate 20 per cent	Injected	"	5	0	1.80	5.71
	Smeared	"	5	2	1.61	
	Brushed	"	5	0	2.30	
Acidulated Mercuric Chloride 1 per cent	Injected	Slight damage	0	0	0	0
	Smeared	"	0	2	0	
	Brushed	"	0	0	0	
Elgetol 2 per cent	Injected	No effect	3	0	1.41	4.19
	Smeared	"	3	3	1.47	
	Brushed	"	3	2	1.31	
"D.N.C. Winter Wash" 25 per cent	Injected	"	6	3	2.73	4.84
	Smeared	"	0	1	0	
	Brushed	"	6	0	2.11	
Copper Sulphate Sat.aq.soln.	Injected	Plants killed	-	-	-	0
	Smeared	Mod. damage	0	0	0	
	Brushed	Plants killed	-	-	-	
Potassium Dichromate Sat.aq.soln.	Injected	Plants killed	-	-	-	0
	Smeared	Slight damage	0	2	0	
	Brushed	Plants killed	-	-	-	
"Puratized" 50 per cent	Injected	No effect	0	0	0	0
	Smeared	Mod. damage	0	0	0	
	Brushed	No effect	0	0	0	
Water (control)	Injected	"	12	3	8.60	23.32
	Smeared	"	12	8	8.30	
	Brushed	"	12	8	6.42	
Differences necessary for significance		5 per cent			3.07	5.32
		1 per cent			4.08	7.07

* Includes galls at inoculation points only.

TABLE II. EFFECTS OF TREATMENTS APPLIED TO GROWING BACTERIAL GALLS

Treatment		Effect of Treatment on Plants	Number of galls killed (12 treated)	Gall diameter increase in cm	
Material	Method of application			Average diameter increase of 12 galls 46 days after treatment	Average for 36 galls
Streptomycin I 300 units	Injected	No effect	0	0.52	0.49
	Smeared	"	0	0.42	
	Brushed	"	0	0.54	
Streptomycin II 1500 units	Injected	"	0	0.40	0.45
	Smeared	"	0	0.41	
	Brushed	"	0	0.54	
Streptomycin III Crude 20 units	Injected	"	0	0.37	0.55
	Smeared	"	0	0.66	
	Brushed	"	0	0.64	
Metnyl Salicylate 20 per cent	Injected	"	10	-0.06	0.19 *
	Smeared	"	0	0.34	
	Brushed	"	0	0.28	
Acidulated Mercuric Chloride 1 per cent	Injected	Slight damage	9	-0.21	0.02 *
	Smeared	No effect	0	0.27	
	Brushed	"	3	0.01	
Elgetol 2 per cent	Injected	Mod. damage	8	-0.08	-0.06 *
	Smeared	No effect	12	-0.27	
	Brushed	"	3	0.18	
"D N.C. Winter Wash" 25 per cent	Injected	"	6	0.03	-0.03 *
	Smeared	"	11	-0.24	
	Brushed	"	5	0.11	
Copper Sulphate Sat.aq.soln.	Injected	5 pls. killed	-	-	-0.28 *
	Smeared	No effect	12	-0.22	
	Brushed	"	12	-0.34	
Potassium Dichromate Sat.aq.soln.	Injected	All pls.killed	-	-	-0.19 *
	Smeared	No effect	10	-0.01	
	Brushed	"	12	-0.38	
"Puratized" 50 per cent	Injected	"	12	-0.26	-0.24 *
	Smeared	"	12	-0.24	
	Brushed	"	12	-0.23	
Water (control)	Injected	"	0	0.66	0.67
	Smeared	"	0	0.74	
	Brushed	"	0	0.60	
Differences necessary for significance		5 per cent		0.15	0.25
		1 per cent		0.19	0.33

* Highly significant

When applied to growing bacterial galls all chemical solutions either killed galls or greatly retarded their further development. The antibiotic solutions streptomycin I, II and III did not kill galls nor did they significantly* retard gall development. "Puratized" gave complete control of galls without visibly damaging plants. Similar effects were obtained when copper sulphate and potassium dichromate were brushed or smeared on galls but when injected into galls, these materials killed the plants.

No one method of application was consistently superior to the other two. Thus methyl salicylate and acidulated mercuric chloride gave almost complete control when injected into galls, but when smeared on, neither substance killed any galls. Elgetol and "D.N.C." however were most effective when smeared on and least effective when brushed on, while copper sulphate and potassium dichromate were most effective when brushed on. "Puratized" was equally effective whether by injection, smearing or brushing. Materials causing plant damage were more harmful when injected into, than when smeared or brushed on galls.

* At the 5 per cent level of significance.

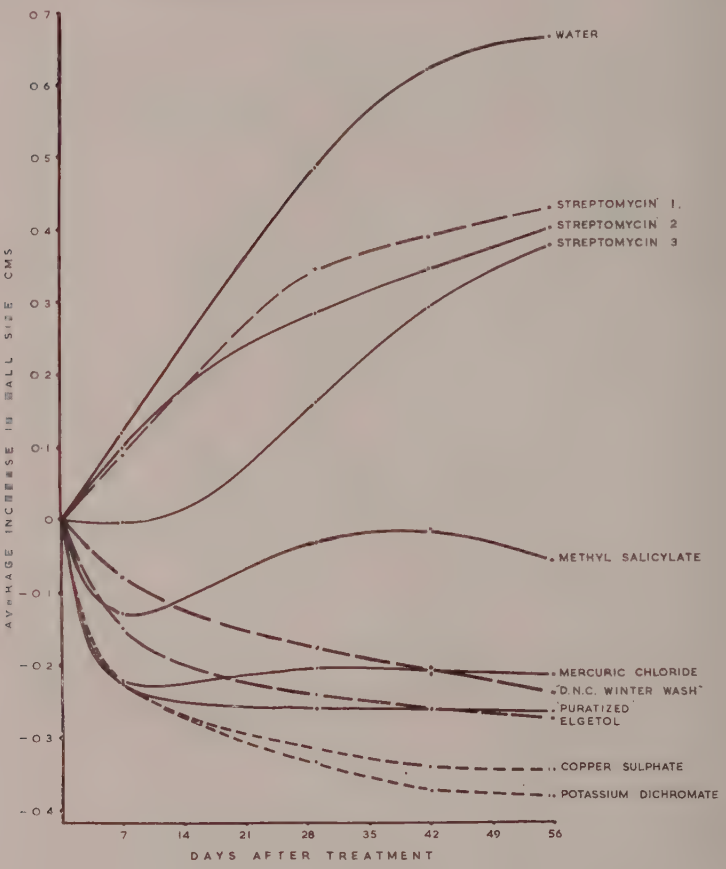

FIG. 1.—The effect of chemical and antibiotic substances on growth rate of marigold galls. The most efficient method of application of each material (see Table II) is shown.

———————— = injected into galls.
— — — — — — = smeared on galls.
– – – – – – – = brushed on galls.

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COLEOPHORIDAE (LEP.) AS PESTS OF CLOVERS

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(*Received for publication, 12 March 1951*)

Summary

The occurrence of *Coleophora frischella* L. on white clover in New Zealand is recorded for the first time. The species is multi-brooded and is of more economic importance than the single brooded *C. spissicornis* Haw. which also occurs in New Zealand. *C. deauratella* Zell. is recorded in Tasmania. The adults of these three species are keyed and biological observations on the first two are given.

Introduction

Meyrick[1] records the following species of *Coleophora* as feeding on Papilionaceae in Europe :—

C. spissicornis Haw. – *Trifolium arvense.*
C. deauratella Zell. – *Trifolium sp.*
C. frischella L. – *Melilotus altissimus* (= *officinalis*)
C. discordella Zell. – *Lotus corniculatus.*

The existing information on the food plants of *Coleophora* spp. is fragmentary, and it is likely that all of the above species feed on a number of different clovers. Hammer[2] records *spissicornis* as feeding on *Trifolium pratense* and *T. repens* while the author has found *frischella* to feed on *T. repens* and *T. fragiferum.* He has been able to find no records of North American *Coleophora* spp. on clovers.

Three of these European species of *Coleophora* are present in the Southern Hemisphere : *spissicornis*, recorded by Lindsay[3] and Hamilton[4] in New Zealand ; *deauratella*, recorded by Meyrick in Tasmania*; *frischella*, which is here recorded for the first time in New Zealand.

These three species fall in Meyrick's group, having immaculate, unicolorous, brassy-bronze wings. They may be separated by the following key, in which the characters of *deauratella* are taken from the descriptions and figures of Pierce and Metcalf[5].

Key to Coleophora Species in Australia and New Zealand

(1) Proximal half of antenna shaggy, black ; distal half banded black and white ; male genitalia (Fig. 1c) with two strong setae, one on valve and one on sacculus. ... ... *spissicornis* Haw.
Antennae very shortly shaggy proximally, black except for distal fourth which is white ; male genitalia without stout setae ... ... (2)

(2) Female (Fig. 2a) with ostium plates on eighth sternite fused distally in median line to form a deep rounded median emargination ; ostium broad, semicircular ; spinose area on ductus bursae three times as long as eighth segment ; male (Fig. 2c) genitalia with sacculus rounded before point which is short and blunt. ... ... *frischella* L.
Female (Fig. 1a) with ostium plates not fused ; ostium more flask-shaped ; spinose area on ductus shorter ; male genitalia with sacculus angulate before point which is longer and more acute. ... ... *deauratella Zell.*

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* Specimens of *Coleophora* since received from Mr. L. W. Miller of Hobart appear to be identical with *frischella.*

BANDED CLOVER CASE-MOTH *Coleophora spissicornis*, Haw.

In this species, the scales of the shaggy basal half of the antenna are longer than the antennal segment. Distally, about 20 segments of the antenna are banded, each segment being black-scaled on the basal half and white-scaled on the apical half. The eighth segment in the female is nearly twice as long as wide ; dorsally (Fig. 1b), it has a medium sclerite which is divided into two para-median arms each ending caudally in a lobe bearing a seta ; ventrally (Fig. 1a), the ostium is flask-shaped and has three or four internal setae on each side ; the ostium plates are obliquely truncate and separated in the median line ; the spinose area on the *ductus bursae* is one and a half times the length of the eighth segment.

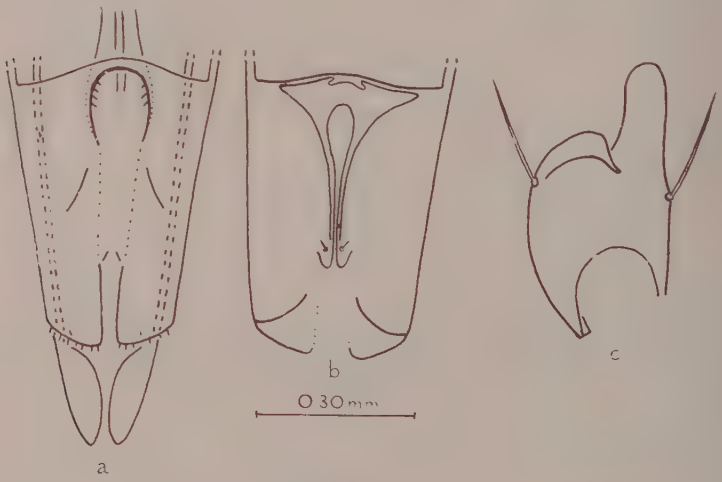

FIG. 1.—*C. spissicornis*.
(a) Female, 8th sternite, ventral.
(b) „ „ dorsal.
(c) Male, valve (or harpe) and sacculus.

In New Zealand *spissicornis* is known with certainty from Ashburton, Governor's Bay, Blenheim and Nelson in the South Island and from Foxton and Hastings in the North Island. It probably occurs throughout the country. The flight period of the moth is from late October to early January though individual stragglers were taken early in February. The largest moth population—87 moths in 100 sweeps with an 8 in. diameter net—seen in the field was in late November at Hastings. Light trap records supplied by R. A. Cumber show the flight period at Foxton as November and December. The species is single brooded in New Zealand as it is also in Denmark according to Hammer[1]. Larvae in cases found on white clover collected in late December showed no sign of pupation two months later. The only food plant known with certainty in New Zealand is White Clover (*T. repens*). One field examined in Hastings appeared to have virtually a pure infestation of *spissicornis*. The single brood and the early appearance of this brood in relation to the flowering and harvesting times of commercial seed crops of white clover, and the early or Broad-Red clover, probably

explain the apparent unimportance of *spissicornis* on these two clovers in New Zealand. The only recorded instance of economic damage by this species was on red clover in Denmark. No parasites of this species are recorded in Europe.

WHITE-TIPPED CLOVER CASE-MOTH (*Coleophora frischella* L.)

In this species the first two or three antennal segments are slightly more shaggy than the remainder, but the scales on these are not longer than the antennal segments. The apical fourth— about ten segments— is white-scaled, though each segment may show dark median spots ventrally. The eighth segment of the female is not much longer than it is wide ; dorsally (Fig. 2b) the median sclerite is not divided, but may carry two pairs of sub-apical setae ; ventrally (Fig. 2a) the ostium is semi-circular with three or four internal setae on each side. The spinose area of the *ductus bursae* is three times as long as the eighth segment.

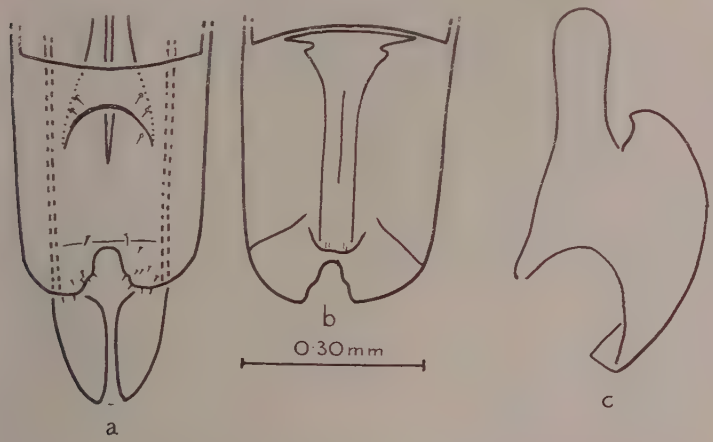

FIG. 2.—*C. friscella.*

(a) Female, 8th sternite, ventral.
(b) „ „ dorsal.
(c) Male, valve (or harpe) and sacculus.

There are no obvious differences between the signa in *spissicornis* and *frischella*. The aedeagus also is very similar in the two species. In *spissicornis* it is conical distally, and in *frischella* cylindrical, but this may be due to differences in the condition of the material mounted, as the distal half is less sclerotised and is liable to collapse unless the protruded ductus supports it.

In New Zealand, *frischella* is known from Timaru, Ashburton, Blenheim and Nelson in the South Island, and from Hastings and Foxton in the North Island. It probably occurs throughout New Zealand. The flight period of the moths is from late October to March or April. Light trap records at Foxton, supplied by R. A. Cumber, show the peak of numbers in January, when the total catch of *frischella* was more than ten times greater than the catch of *spissicornis*. The first adult *Coleophora* seen —at the beginning of November—proved to be *frischella*, and a second brood of adults of this species commenced emerging from ripe white clover heads on 18 December. Eggs taken from white clover heads had all hatched in seven days after collection but they may have

been two or three days old when collected. Cased larvae pupated and produced adults in a minimum of twelve days after leaving the heads. The larval period is probably about four weeks and the spring or early summer brood occupies about seven weeks. It is likely that there is a third brood and possibly even a partial fourth brood. A few cases, from which *frischella* emerged have been taken from *T. pratense* but actual damage to the seed has not yet been observed. *C. frischella* has also emerged from cases taken from *T. fragiferum* heads and *Coleophora* larvae have been found in the seeds of this clover.

The following European parasites of this species are recorded by Thompson[6]:–

Gelis palpator Grav.

Hemiteles palpator Grav. – on other *Coleophora* spp. also.

Pimpla brevicornis Grav. – has a wide host range and may be a hyperparasite in some conditions.

General

No characters have so far been found for the specific separation of the larvae and cases.

A nematode parasite (? *Neoaplectana* sp.) is present in New Zealand. Three out of twenty overwintering *Coleophora* larvae recovered from the soil at Blenheim were found to be parasitised.

A paddock where white clover seed was damaged in the 1949-50 season was found in the spring of 1950 to have a living larval population of the order of twenty per square foot. A younger paddock nearby had a population of five per square foot.

From 110 white clover heads collected in late December, 83 *frischella* emerged, and from 31 heads collected in early January, 38 *frischella* emerged.

No indication has been seen that the overwintering larvae feed in spring prior to pupation, though they may move position to a site more favourable for emergence.

First instar larvae are found inside the young green seeds, while larger larvae may eat the inside out of the nearly mature seeds. It is probable that a large percentage of the damaged seed is so light that it is blown out of the machine during harvesting, and the percentage of damaged seed in field-dressed lots does not represent the total damage. Accurate figures of losses are not yet available but it is known that some apparently promising crops are not harvested because of low seed yields due to *Coleophora* damage. Heavily damaged crops occur sporadically in a district, and it is likely that the management of the pasture may have an important influence on the development of large *Coleophora* populations.

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CHINESE GOOSEBERRIES (*Actinidia chinensis*): A SURVEY OF THEIR BEHAVIOUR IN COOL-STORAGE AT ALL STAGES OF HARVEST MATURITY FROM MAY TO JULY

By C. A. S. Padfield, Fruit Research Station, Department of Scientific and Industrial Research, Havelock North, and F. L. Bailey, Horticulture Division, Department of Agriculture, Tauranga

(*Received for publication, 5 April 1951*)

Summary

Chinese gooseberries harvested during the period from early May to late July can be successfully cool-stored at 31-32°F. for two months. Fruit harvested from late May to mid-June can be held for a longer period.

When stalks were clipped short this fruit travelled well without pads or wrapping. Considerable softening occurred during two months cool-storage and berries in this condition were severely damaged during transit by rail.

Introduction

Previous work had shown that a temperature of 31-32°F. was most suitable for Chinese Gooseberries in cool-store (Padfield, 1950). Fruit used in that experiment had been picked in late June. As harvesting takes place between early May and late July, it was thought necessary to ascertain what happens in storage to fruit harvested over the whole of this period.

Experimental Procedure

Fruit was picked in Tauranga, once a fortnight during May and June, and weekly during July. These periods were selected to cover the normal harvesting season. Four 20-lb. cases were stored from each picking. Previous experience had shown that damage in transit was often caused through stalk stubs puncturing adjacent fruit; also, if cases were over-filled, berries were split by uneven case-timber.

Stalks were clipped right to the base of the berries to overcome puncturing. To avoid splitting, and to assess the value of using pads in the cases, one case of each picking was lined with an all-round corrugated pad, one was lined with top and bottom pads, while the remaining two had no protection of any kind. Fruit was picked and forwarded by rail to Hastings. On arrival, each case was examined for puncturing, splitting, or other damage. All fruits in these categories were rejected. Immediately after this examination all fruit was stored at 31-32°F.

Detailed examinations were not commenced until after each picking had been in cool-storage for two months, and thereafter, at monthly periods, or at such time as each picking warranted. Only one case from each picking was examined at any one time, the remainder being held for later examination.

Berries were sorted into the following grades: "Firm", "Soft", "Very soft", and "Split and mouldy".

To obtain an idea of the condition in which the fruit would arrive at the market, each case was held at air-temperature for a further four days, after which it was re-examined and graded as before.

TABLE I. EFFECT OF COOL-STORAGE AT 31-32°F ON CHINESE GOOSEBERRIES PICKED THROUGHOUT THE PICKING SEASON
(All results expressed in percentages)

Case	Examination date	Firm	Soft	Very Soft	Mouldy &/or Split	Firm	Soft	Very Soft	Mouldy &/or Split
Pick 1	Picked 1/5/50	Stored 5/5/50							
A	10. 7.50	57	28	14	1	29	43	28	-
B	28. 7.50	50	28	20	2	40	29	31	-
C	25. 8.50	25	42	31	1	2	17	81	-
D	8. 9.50	-	6	75	18	Bulk of fruit very soft			
Pick 2	Picked 22.5.50	Stored 26.5.50							
A	25.7.50	64	29	7	-	61	25	13	-
B	18. 8.50	67	21	10	2	55	27	18	-
C	15. 9.50	74	13	13	-	69	15	15	-
D	16.10.50	-	3	67	28	Bulk of fruit very soft			
Pick 3	Picked 29.5.50	Stored 2.6.50							
A	28. 7.50	71	23	5	1	66	22	11	-
B	25. 8.50	72	24	4	-	65	22	13	-
C	22. 9.50	32	25	42	1	8	31	61	-
D	6.10.50	2	7	89	2	Bulk of fruit very soft			
Pick 4	Picked 12.6.50	Stored 16.6.50							
A	14. 8.50	90	6	4	-	65	28	8	-
B	8. 9.50	74	21	6	-	69	22	10	-
C	6.10.50	56	26	19	-	40	28	32	-
D	20.10.50	17	32	48	3	Bulk of fruit very soft			
Pick 5	Picked 3. 7.50	Stored 10. 7.50							
A	4. 9.50	46	39	15	-	29	36	34	-
B	2.10.50	20	39	39	2	3	23	74	-
C	20.10.50	-	81	17	3	Bulk of fruit very soft			
D	20.10.50					"	"	"	"
Pick 6	Picked 10. 7.50	Stored 17. 7.50							
A	11. 9.50	59	29	11	1	46	37	15	1
B	9.10.50	49	20	25	6	29	25	46	1
C	20.10.50	41	14	31	14	Bulk of fruit very soft			
D	20.10.50					"	"	"	"
Pick 7	Picked 17.7.50	Stored 24.7.50							
A	18. 9.50	88	9	3	-	73	21	6	-
B	16.10.50	20	28	48	4	10	19	61	9
C	20.10.50					Bulk of fruit very soft			
D	20.10.50					"	"	"	"
Pick 8	Picked 24.7.50	Stored 28.7.50							
A	22. 9.50	69	24	6	-	69	21	11	-
B	20.10.50	19	17	49	15	Bulk of fruit very soft			
C	20.10.50					"	"	"	"
D	20.10.50					"	"	"	"

A small 10-lb. case of berries had also been forwarded with each picking. On removal, these were immediately railed back to Tauranga and examined on arrival.

RESULTS

Protection during transit

Examinations made on arrival from Tauranga showed that, provided stalks had been completely removed and fruit had been packed carefully, there was no necessity for any form of padding in the cases. No results are presented, but in the total of 37 cases of all sizes forwarded there were only a few damaged berries. This travelling provided a very severe test for the fruit, as it underwent at least a four-day cross-country rail journey, which involved considerable shunting.

Cool-storage

Results recorded after each period of cool-storage, together with picking and storage dates are presented in Table I. From the point of view of market quality, good marketable fruit can be considered as that falling into the "firm" and "soft" categories. It can be seen that fruit picked in early May did not have the same storage life as that picked in late May, or in early and mid-June. When picked during this latter period, it had the greatest potential for long-term cool-storage. Fruit of the July pickings was unsuitable for more than two months storage. This is further emphasised by the fact that Case D of Pickings 5, 6, 7 and 8, and Case C of Pickings 7 and 8 had deteriorated to such a degree that detailed examinations were unwarranted. Results indicate that berries of any maturity will cool-store for two months, and continue to be satisfactory even after they have been out of storage for four days.

TABLE II. EFFECT OF 4-DAY RAIL JOURNEY ON CHINESE GOOSEBERRIES AFTER 2 MONTHS COOL-STORAGE
(All results expressed as percentages)

Original picking date	Date examined	Firm	Soft	Very Soft	Over soft, split, or Damaged	Total collapse	Mould
1. 5.50	31. 8.50	-	-	-	41	59	-
22. 5.50	6. 9.50	28	29	21	16	5	-
12. 6.50	12. 9.50	23	54	7	7	2	6
3. 7.50	5.10.50	29	31	9	32	-	-
10. 7.50	12.10.50	-	-	5	50	44	-
17. 7.50	19.10.50	-	20	30	19	31	-
24. 7.50	19.10.50	2	25	29	27	17	-

Fruit transported after cool storage

Table II presents results of small 10-lb. cases examined at Tauranga after return from Hastings. Although these examinations were not carried out after uniform periods of storage they substantiate to a degree the results obtained in Hastings, that mid-season fruit is the most suitable for cool-storage. These figures suggest that, if chinese gooseberries are to be stored at all, this should be done at the point of marketing and not at the orchard. Rates of softening are such that fruit will not carry for long distances after two months' storage.

A brownish colouring was noted in the flesh of the last two consignments at Tauranga and was also apparent in fruit examined in Hastings. Specimens were forwarded to the Plant Diseases Division for identification of any destructive organism. Cultures of *Alternaria* and *Penicillium* spp., together with soft-rotting bacteria were isolated. These are all soft-rotting organisms which may be expected to develop on soft-fleshed fruits such as chinese gooseberries, particularly after long-period storage when fruit is fully mature.

Acknowledgments

The authors are indebted to Mr. R. S. B. Greensill of Tauranga for supplying fruit for this experiment.

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REVIEWS

PHYSICAL CHEMISTRY FOR PREMEDICAL STUDENTS

By John Page Amsden. International Chemical Series. McGraw Hill: Second Edition, 1950. 317 pp. Price $4.25

The medical student has a long course and is usually loath to spend much time on mathematics, physics and chemistry before setting out on the subjects which he considers of more direct value to him. If he has his future salary in mind, he will not wish to postpone the already distant day when he will reap his first fruits, by inserting extra subjects in his student course. For medical practice, it is certainly doubtful whether any increase in the elementary physics, chemistry, and zoology, which constitute the present medical intermediate course, is necessary for the practitioner.

Physical chemistry is making its contribution to knowledge and to medical knowledge in particular, by the application of mathematical and physical methods to the elucidation of chemical systems, including the very complex systems of living things. It is not usually taught until the later years of a science degree, when a proper groundwork of mathematics and physics may be expected.

Professor Amsden has attempted the very difficult task of teaching physical chemistry without this groundwork. In the one term, which he allows for this subject, he not only covers the large portion of physical chemistry, which " should enable the student to read, understand, and apply much of the work that is being reported in the current literature," but also attempts to remedy the lack of background of his readers by spending precious pages on the calculation of the strength of a solution made by diluting a solution of known concentration, and on definitions of electrical terms, such as capacity. It is not easy to write a book, which will be useful both to a student for whom such explanations are necessary, and to one who has developed the skill of abstract mathematical thinking sufficiently to grasp the principles of thermodynamics, outlined in Chapter 8.

It is a temptation to a teacher to substitute a simple illogical proof for a difficult logical one—especially if the illogicality is easily glossed over. This habit is justified if one takes the view that the end justifies the means, since time and effort, which are scarce commodities in a premedical course, are undoubtedly saved. The temptation is greater when the reader is not expected to have a sufficient grounding to follow the correct proof. The derivation of the equilibrium constant from the rates of forward and reverse reactions is incorrect, since very few equilibria are known where the rates of the forward and reverse reactions depend on the concentrations of the reactants and products in the simple manner required by the proof.

The treatment of acids and bases as proton donors and acceptors is admirable, and the thorough and modern treatment of acid—base equilibria in water and salt solutions seems a very wise and helpful selection of material.

In New Zealand, the medical student intending to use physical chemistry in his future medical researches must precede his medical course with a degree in Science. The very complex systems with which he will deal, demands that he add these extra years to his long training. In this case, he will find this book too elementary. If, on the other hand, he is content with the general chemistry of the intermediate course, he will find this book beyond him unless he has been particularly well equipped at school in mathematics and physics.

The printing and binding leaves nothing to be desired—the good taste and quality in the design of books of this series is well-known.

W.S.M.

DIRECTORY OF NEW ZEALAND SCIENCE

EDITED FOR THE NEW ZEALAND ASSOCIATION OF SCIENTIFIC WORKERS BY LYNDON BASTINGS, D.Sc., F. INST. P. Published by Harry H. Tombs Ltd., Wellington, 1951. 188 pp.

In 1948 appeared under the above auspices a " Directory of New Zealand Scientists", in the 107 pages of which were listed, with concise details, over 1100 names of workers in science. That a new edition should appear so soon seems to evidence that the publication was found useful for reference.

This new edition has the title " Directory of New Zealand Science ", and is divided into four main sections dealing with : (a) New Zealand Scientists (some 1300 entries, just over 100 being women); (b) Post-primary Teachers of Science (339, about 25 per cent. women, unfortunately without reference to subjects taught); (c) New Zealand Suppliers of Scientific Apparatus and Equipment (106); (d) New Zealand Scientific Institutions (94). There are also a classified index of subjects, an alphabetical index of persons, and an alphabetical list of periodicals and other serial publications (58 entries). The typography is praiseworthy, and the proof-reading has been remarkably good.

The three additional sections greatly improve the usefulness of the work, but for most readers the main interest will still lie in the list of workers. One has to seek the principles underlying the selection of names. A clear statement of the intended scope would have been welcome, and one still wonders what the term " scientific worker " is really meant to convey.

One finds a total of nearly 1400 entries (some scientists claim more than one discipline): Mathematics accounts for 34, Astronomy 7, Physics 164, Chemistry 398, Geology 95, Engineering 124, Biology pure and applied 452 (including Agriculture 126, Botany 72, Forestry 35, Zoology 77), Ethnology and Anthropology 15, and Psychology 17. Lesser groups swell the total ; 26 claim inclusion as administrators or liaison officers. Of the 104 women in the main list, over 50 per cent prefers a biological subject ; chemistry, with 21 persons, is also strongly represented ; Home Science has 12.

Administrators might find the work useful in determining how far the field of science is adequately covered in New Zealand. Are there really only 17 workers in Medical Science in the country ; has Horticulture no more than 11 ; are there only 8 Geographers worthy of mention ; and are there no " scientific workers " among the Cartographers ? Historians play a useful part and might have been included. Is Building Science adequately attended to (only two concerned with this are mentioned)? The fields of " Mathematical Physics, Geodesy, Surveying, etc." have apparently a bare six workers all told. Has the term " Mathematical Statistics " a subtle meaning and implication ?

But to cease carping, all cognizant of the difficulties of such an undertaking, will wish to congratulate the editor on the measure of success achieved, and the mass of information made readily available.

H.H.A.

A SYNOPSIS OF THE WORLD LITERATURE ON THE FRUIT TREE RED SPIDER MITE *Metatetranychus ulmi* (C. L. KOCH, 1835) AND ITS PREDATORS

By Joan R. Groves, B.Sc., with a brief review of the problem by A. M. Massee, D.Sc., F.R.E.S., 180 pp. London, 1951. 20s.

The ravages of red spider mites have long forced them upon the notice of horticulturists and orchardists. The economic importance and wide distribution of these mites is illustrated by the fact that Miss Groves has compiled an annotated bibliography comprising 1,039 papers dealing primarily with one species, the fruit-tree red spider (*Metatetranychus ulmi*) and its predators. The synopsis is preceded by a four-page review of the problem by Dr. A. M. Massee. This introduction by Dr. Massee gives an admirable but all too brief summary of the systematics, biology and control of *M. ulmi*. Some problems encountered in the study of this mite are mentioned, e.g., the difficulty of assessing the results of control experiments in the field, and the lack of knowledge of the factors causing populaton fluctuations. One point of wider interest raised by Dr. Massee is that we know all too little about the general effect of a spray on the fauna of an orchard as a whole, when such spray is applied against one species of insect or mite.

In her preface, Miss Groves indicates that some references to allied red spider species have been included. The bibliography is divided into two parts: the first 821 references relating to *M. ulmi* and the remaining 218 to its predators. The contents of each paper are arranged under headings such as systematics, bionomics, dispersal, etc. Unfortunately most of the synopses are very brief, many of the systematic papers being referred to by title only. In general, however, the annotations represent an adequate compromise between brevity and clarity.

An introductory list of synonyms and popular names raises some debatable points. Thus *Tetranychus urticae* Koch, *T. bimaculatus* Harvey and *Epitetanychus altheae* von Hanstein are listed as synonyms of *T. telarius* (L.), whereas most modern European and American workers regard them as distinct species. There is also some doubt whether or not *T. uniunguis* Ewing is synoymous with *Paratetranychus ununguis* (Jacobi).

Examination of the abstracts leaves one with two outstanding impressions. The first, familiar to all workers interested in the systematics of the Tetranychidae, is the nomenclatural morass associated with species terminology in this family. It would seem that the time is long past when the systematists in Europe, Britain and the United States should come to some common agreement regarding an acceptable terminology for the main species—particularly the fruit-tree red spider and "*Tetranychus telarius*." The second impression is that there has been, and still is, an enormous amount of duplication of effort in therapeutant work in relation to the control of *M. ulmi*. This literature synopsis will be of considerable value to research workers if its helps to eliminate some wasted effort.

Omissions are inevitable in a work of this nature. For example, one would like to have seen Zacher's review in 1933 of the German spider mites (Mitt. Zool. Mus. Berlin. *19*, 584-9) and McGregor and Newcomer's 1928 paper on the taxonomic status of the deciduous fruit-tree red spider with reference to the citrus mite (J. Agr. Res. *36* (2), 157-81). Few papers which appeared after 1947 have been included, and it is pleasing to note that the authors propose to publish a supplement. Since 1947, a large number of papers relating to chemical control have appeared and in view of rapid modern advances in the development of organic acaricides, present day control recommendations are in a state of flux.

This well-produced synopsis of literature is a comprehensive publication which will be indispensable to the economic entomologist. It is a tribute to the industry and breadth of reference of its authors.

K. P. L.

COMPARATIVE ANIMAL PHYSIOLOGY

By C. LADD PROSSER (Editor), DAVID W. BISHOP, FRANK A. BROWN, THEODORE L. JAHN, and VERNER J. WULFF. W. B. Saunders Co., Philadelphia and London, 1950. 888 pp., 312 figs. (N.Z. Agents, N. M. Peryer Ltd., Christchurch.) Price £4-7-6.

The present work is a comprehensive text book based on the knowledge and experience of five well known authorities on animal physiology and, is documented by quotations from all the essential material published by other workers. It brings into one treatise an exposition of the whole subject from Protozoa to man. Furthermore, it treats animal physiology in its broader relationships with ecology and phylogeny ; the authors rightly point out that the functional adaptions of organisms to their environment is foremost among the principles which emerge from a study of comparative physiology.

A considerable amount of space is given to the water relation, especially osmosis, and the adaptions of animals to fresh water, marine and parasitic life. Antigenic specificity of serum proteins, it is held, can be used with other characters to study the relationships of animals. As an example, the relations of echinoderms to protochordates have been corroborated. The chapter on endocrine mechanisms is especially full and interesting. It is concluded that the endocrine system influences primarily functions in which the time to induce a response is long, and, generally, when the controlling influence needs to be maintained over long periods of time.

The scope of the work is shown by the chapter headings : water, inorganic ions, protein specificity, nutrition, feeding and digestion, nitrogen excretion, respiration and metabolism, temperature, photoreception, chemoreception, phonoreception, mechano- and equilibrium-reception, circulation of body fluids, muscle and electric organs, amoeboid movement, cilia, trichocysts and nematocysts, bioluminescence, chromatophores and color change, endocrine mechanisms, nervous system.

Animal physiology is one of the integral parts of biology and as such is of interest to biologists, both teachers and students, and to those whose vocations call for a knowledge of the subject, such as medical men, veterinarians and stock breeders.

W.R.B.O.

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